AD NUMBER
ADB102932
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies only; Proprietary Information; MAR 1982. Other requests shall be referred to Foreign Broadcast Information Service, PO box 2604, Washington, DC.**
AUTHORITY
USITAC ltr 7 Mar 1989

THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOD DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

PHOTOGRAPH THIS SHEET

AD-B102 932

DTIC ACCESSION NUMBER

LEVEL

INVENTORY

(1)

TRANSLATION

TANKS AND TANK TROOPS

DOCUMENT IDENTIFICATION

Distribution limited to U.S. Gov't. agencies only; Proprietary Info.; 17 JUL 1986. Other requests for this document must be referred to Foreign Broadcast Information Service 212 Key Bldg., P.O. Box 2604 Wash., D.C. 20013

DISTRIBUTION STATEMENT

ACCESSION FOR		
NTIS	GRA&I	☐
DTIC	TAB	☑
UNANNOUNCED		☐
JUSTIFICATION		

BY

DISTRIBUTION / AVAILABILITY CODES

DIST	AVAIL AND/OR SPECIAL	
B-3		

DISTRIBUTION STAMP

DTIC ELECTE JUL 17 1986 S D D

DATE ACCESSIONED

DATE RETURNED

86 7 15 070

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NO.

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDAC

FOR OFFICIAL USE ONLY

ATC-PD-1120-084-82

DEPARTMENT OF THE ARMY
UNITED STATES ARMY INTELLIGENCE AND SECURITY COMMAND
UNITED STATES ARMY INTELLIGENCE AND THREAT ANALYSIS CENTER

AD-B102 932

Translation

TANKS AND TANK TROOPS (U)

MARCH 1982

Distribution limited to USGO, Proprietary Information, Mar 1982. Other requests must be referred to Foreign Broadcast Information Service.

FOR OFFICIAL USE ONLY

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PREFACE

The Soviet publication, Tanks and Tank Troops, was translated by the Joint Publications Research Service (JRPS). As a result of 2Dec81 letter request of OACSI, HODA, USAITAC reprinted the JPRS translation to increase dissemination of this open source material in the Army.

~~Additional copies of this publication may be ordered from the National Technical Information Service (NTIS), Springfield, VA 22161. In ordering, it is recommended that the JPRS number, title, date and author be cited.~~

NOTE: The reverse side of this page is blank.

JPRS L/9697

29 April 1981

Translation

TANKS AND TANK TROOPS

Ed. by

A.Kh. Babadzhanyan, et al.

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE: The reverse side of this page is blank.

JPRS L/9697

29 April 1981

TANKS AND TANK TROOPS

Moscow TANKI I TANKOVYE VOYSKA in Russian 2d ed, supplemented 1980 (signed to press 14 Mar 80) pp 1-432

[Book published under the general editorship of A.Kh. Babadzhanyan, Voyenizdat, 25,000 copies, BBK 68.513 T13 UDC 623.438.32+358.119(001.1)]

CONTENTS

[II - USSR - FOUO]
[III - USSR - 4 FOUO]

ANNOTATION

The volume "Tank i tankovyye voyska" was written by a team of professors and instructors at the Armored Troops Academy imeni R. Ya. Malinovskiy, officers from the central edifice of the USSR Ministry of Defense and from the Guards Kantemirovskaya Tank Division, under the direction of Doctor of Military Sciences Prof Col P. G. Skachko.

The group of authors includes Doctor of Technical Sciences Prof Engr-Maj Gen L. V. Sergeyev; Prof Engr-Maj Gen A. S. Belonovskiy; Doctors of Military Sciences Prof Cols P. G. Skachko, P. Ya. Oreshkin, and N. K. Shishkin; Doctors of Technical Sciences Profs M. K. Maryutin and V. I. Medvedkov; Candidates of Military Sciences Docents Cols S. V. Vasil'yev, V. M. Derevyanskiy, A. V. Polyakov, and V. S. Chernov; Candidates of Technical Sciences Docents Engr-Cols A. G. Burlachenko, N. S. Galandin, V. V. Kiselevskiy, V. A. Mangushev, E. D. Prikhod'ko, and A. G. Solyankin; Engr-Col M. D. Zhurko; Gds Sr Lt V. P. Skachko.

The volume was readied for publication by Cols P. G. Skachko and N. K. Shishkin and Engr-Col V. V. Kiselevskiy.

Chief Mar Armed Trps A. Kh. Babadzhanyan (deceased) served as general editor.

NOTE: The reverse side of this page is blank.

FOREWORD

The years which have passed since publication of the first edition of this work have fully confirmed the conclusions and forecasts of the authors pertaining to the place and role of tanks under present-day conditions and in the foreseeable future.

The aggression in Vietnam, the India-Pakistan conflict and the Arab-Israeli war demonstrated that the tank continues to be a formidable combat weapon. This is due to the fact that the tank beautifully combines the excellent qualities required for battle: firepower, striking power, maneuverability and mobility, as well as protection against the principal weapons.

As a result of development of modern means of transportation, the tank has become transportable for all modes of transport, including air. This has increased to an even greater extent the tank's potential and significance as a weapon.

Predictions by skeptics that appearance on the battlefield of antitank guided missiles (ATGM) would bring to an end the tank's domination of the field of battle have not come true. Conclusions on the role and place of tanks in future wars, made by Soviet military science even before World War II, would remain valid after that war as well. The laws and patterns of employment of tank troops, discovered by our science, have not lost their practical significance. The development of powerful antitank weapons, including ATGM, has not diminished the significance of tanks.

Research and improvement in the military area are opening up new horizons, which are truly boundless. Together with the development of military hardware and knowledge of military affairs, new problems arise in the art of warfare, problems which form obstacles in the path of efficient utilization of new equipment and employment of new methods of concepts arising on the foundation of new knowledge.

In order to move forward it is necessary to resolve these problems in a prompt and timely manner and to proceed now with penetrating into the essence of those phenomena and processes which will arise in a future war, if aggressive forces initiate a war. In the course of war there will scarcely be time to correct erroneous concepts. Commanders of all echelons will have too little time to acquire experience during combat operations. Therefore it is doubly essential to test and verify now, element by element, already existing and newly developed concepts to as thorough a degree as is possible. Questions pertaining to the present and future of tank troops acquire particular importance in this regard.

Practical experience and theory become rapidly obsolete in a time of swift advance of technology. Development of weaponry in the postwar years evoked many new ideas in military affairs. We are witnesses to a reassessment of values. Debates on the role and influence of services and arms on the course and outcome of war have continued up to the present day.

Nor has this process bypassed tank troops. Today, however, there are no longer any doubts about whether the tank is obsolete -- it has become completely obvious to everybody that the tank is needed. At the present time there is a debate in progress abroad about what tank is best under present-day conditions, what its design, layout and armament should be, what combat vehicles should be employed for infantry, and whether large operational formations of tank troops are needed under present-day conditions, when armies have become fully motorized. These are the main problems in development of tank troops which concern theorists and practical experts in military affairs and on which various points of view exist.

It is generally believed today that all the capabilities of modern weapons can be fully utilized in mobile warfare and that the tank is the most powerful means of ground attack for performing many of the combat missions assigned to ground troops. Frequently, however, completely opposite points of view are held by experts in different countries as regards the tank itself, the organizational structure and theory of employment of tank troops. This is quite understandable and logical, for the truth is born in struggle by opposing opinions.

The task of military science in this regard is to reveal correctly and in a timely manner the objective laws and patterns of war and correctly to determine the trends which should be followed by development of armored equipment, organizational forms of development of tank troops, and the principles of their employment in war.

Another aim of the second edition of this work is refinement of these laws, patterns and trends, which are very difficult to see in the streams of new, contemporary information in all areas of military affairs. Therefore they require fuller and more systematized presentation.

The authors of this volume have sought to show the general directions and patterns of development of armored equipment and organization of tank troops, as well as the principles of their employment on the battlefield, without going into details. The authors have also of course taken into account the experience of the past, especially that experience which in their opinion is useful for the future, for success has always attended not he who blindly copied the old but rather he who, overcoming the old, boldly laid new roads forward. In this regard the book can offer tank troop commanders and military engineers as well as the people in the tank industry food for their innovative quest in design, operation and combat employment of tanks.

It is a well known fact that the tank was created by the objective conditions of combat reality. Its role and significance experienced change, beginning on 15 September 1916, when the tank first appeared on the battlefield. Employed initially as an infantry close support weapon, the tank was gradually transformed into a means of infantry and cavalry tactical exploitation. As technical improvements occurred, the tank earned its right to existence and was ultimately transformed into a factor of operational significance.

V. I. Lenin and the Communist Party, attaching enormous importance to the technical equipment of the Red Army, defined the role and place of armored forces in war. Analyzing the conditions of waging war in the machine age, V. I. Lenin reached the conclusion that victory could not be gained without equipment and the ability to utilize it against the adversary in battle. In war, he stated, "victory is won by he who has the greatest engineering, organization, discipline and the best machines..."*

The tank troops established during the first years of Soviet rule became in the hands of the proletariat and its army a powerful means of defense of the Soviet Republic against the imperialist aggressors.

Taking account of V. I. Lenin's statements, Soviet art of warfare had high regard for the operational capabilities of tanks. Elaboration of theory of employment of tanks and establishment of large tank combined units were a result of this. Soviet art of warfare created for the first time in history a theory of the operation in depth, in which tanks were assigned one of the decisive roles.

World War II fully confirmed the correctness of this theory. Large tank formations, working in coordination with air power, performed operational and strategic missions, penetrating deep into the enemy's dispositions. One can boldly state, without denigrating the role and significance of other weapons, that tanks deserve exceptional credit for achieving victory over the enemy in World War II.

The effectiveness of employment of tank troops in World War II was so great that their development after the war proceeded at an accelerated pace in all the armies of the world. The development of nuclear weapons, however, with their enormous destructive force, engendered substantial doubts in the minds of certain foreign theorists and practical experts in military affairs regarding the qualitative composition of the tank inventory, which at that time included three principal types of tanks: light, medium, and heavy. Since the principal role in neutralizing and destroying the adversary was assigned to nuclear weapons, and since they viewed the capture of enemy-held ground as the principal mission of ground forces, it was considered adequate to possess only light tanks and other armored vehicles adapted for airlifting and capable of performing these functions.

The development of antitank guided missiles, which are capable of piercing tank armor of practically any thickness, bolstered this view. In France, for example, only light tanks, armored cars and armored personnel carriers were built for an extended period of time after the war.

The majority of military experts, however, are of the opinion that the necessity of large-scale combat operations dictates that tank troops be equipped with diversified military hardware, including various types of vehicles: tanks, self-propelled guns of various designation, armored cars, armored personnel carriers, and other special vehicles.

Advocates of this view are of the opinion that tanks should constitute the foundation of tank troops -- highly mobile tracked combat vehicles with excellent

* V. I. Lenin, "Poln. Sobr. Soch." [Complete Works], Vol 36, page 116.

cross-country performance and carrying powerful weapons and armor protection. Tanks are designated for performing a broad range of missions, particularly engagement of hostile tanks. They are an offensive weapon which is directly employed to neutralize and destroy the enemy, and therefore they should carry versatile main armament capable of performing the combat missions which they are assigned: conduct of reconnaissance and engagement of hostile armored targets, neutralization and destruction of hostile antitank weapons including artillery, destruction of defensive installations, and killing of enemy personnel. In order to accomplish missions of this kind, tanks should incorporate an aggregate of design features which provide high fire maneuverability.

What has been stated above attests to the impossibility of combining in a single tank model the entire diversity of combat performance characteristics requisite for performing assigned missions. Therefore foreign experts believe that at the present time and in the foreseeable future tanks of differing designation will continue to be designed and built, differing substantially in combat performance characteristics, specifications, and design features.

The existence of several types of combat vehicles, however, results in considerable difficulties both in the area of logistical support and training personnel to operate, maintain and repair these vehicles.

These difficulties engendered the idea of standardization of combat vehicles, in order that all missions assigned to tanks can be performed by a minimal number of tank types.

At the present time the tank inventories of the majority of the world's armies contain a so-called main battle tank, which is capable of performing various missions, particularly such missions as engaging enemy tanks, destroying antitank weapons, destroying defensive installations, and killing enemy personnel. The remaining types of armored fighting vehicles are highly specialized.

In addition, development of tanks and tank troops is influenced to a decisive degree by forecasting the character of a future war, the role of tank troops in a future war, and the modes of their employment. In this regard the principal demand imposed on the tank boils down to its effective utilization in contemporary warfare both with and without the employment of nuclear weapons.

The modern tank is a complex combat vehicle built on the basis of the latest advances in science and technology, while tank troops are highly mobile bodies possessing the greatest capabilities to conduct successful combat actions under various combat situation conditions.

The best of the modern tanks are technically more sophisticated than tanks of the postwar period. They reflect the latest advances in electronics, optics, radio engineering, mechanics, chemistry, and power engineering.

In this edition, as in the previous one, the authors have sought on the basis of unclassified published materials to show the contemporary status of tank troops armored equipment, to discuss problems of adoption of the latest scientific and technical advances, and to examine the future development prospects of armored equipment and tank troops as a whole, without taking an excursion into history.

This volume presents only general trends in the improvement of tanks and the patterns of employment of tank troops. This is the correct approach, because individual points become rapidly obsolete, while the general laws and patterns remain valid for an extended period of time.

This volume can become a desktop companion not only for tankers but also for other officers in our army, since it will help them perceive the role and place of tanks in the ground forces armament system.

Chief Marshal of Armored Troops
A. Babadzhanyan

PART ONE. ARMORED VEHICLES

SECTION I. MODERN ARMORED VEHICLES AND DEVELOPMENT TRENDS

Chapter 1. TANKS

1. Tanks -- Principal and Most Important Category of Armored Fighting Vehicles

The experience of World War II and combat operations in Korea, Vietnam, in the India-Pakistan conflict, as well as in the Near East, confirms that tanks are the most versatile weapon, capable of performing a broad range of combat missions. It is precisely this which determines their role in contemporary wars as the main striking force of ground troops.

The development of armored equipment is today taking place under conditions characterized by the following:

the necessity of effective employment of tanks and other armored vehicles in combat operations both with and without the employment of nuclear weapons;

a high rate of troop advance with a substantial depth of operations;

the fact that armies are armed with large quantities of diversified high firepower antitank weapons, including ATGM, aircraft and, of course, tanks.

The United States, the Federal Republic of Germany, France, and Great Britain are the leading capitalist nations in the manufacture of tanks and other armored fighting vehicles. In addition to these countries, Sweden, Switzerland, and Japan also build tanks of their own design.

The FRG is the leader among the European capitalist countries in production of armored equipment and quantity of armored equipment in its military forces. It has become one of the principal exporters of tanks to countries of the capitalist world. Belgium, the Netherlands, Canada, Norway and Italy, which formerly purchased tanks in the United States and Great Britain, have in recent years adopted the Leopard 1 tank for their armies.

With development of the STB-6 tank at the beginning of the 1970's, Japan joined the group of nations which produce modern tanks. The versions of this tank, which was adopted by the military in 1974, employ the latest tank engineering advances of the leading capitalist countries.

In spite of the great variety of modern armored vehicles, tanks retain their primary importance. At the present time the armies of the capitalist countries have designated as main battle tank one type of tank the combat performance characteristics

and technical specifications of which enable it to be successfully employed to perform an extremely broad range of combat missions. The Western military press began employing the term "main battle tank" for these tanks. The main battle tank combined, as it were, the performance characteristics of medium and heavy tanks (according to the previously employed classification).

Therefore when the discussion deals with tanks, their role, comparison and development, of greatest interest are main battle tanks, the total number of which in modern mechanized (motorized infantry) divisions runs to 200 vehicles, and in tank (armored) divisions -- 300 vehicles and more.

Thus characteristic of the evolution of tanks today is a decrease in the number of types. At the same time one observes a process of decrease in the number of different base vehicles within the framework of total armored equipment, by development of a "family" of vehicles based on one vehicle which is common to the "family." This arrangement greatly simplifies problems of manufacture, supplying spare parts, vehicle reconditioning and maintenance, mastering of the equipment by personnel, and securement of coordination of subunits and units, since as a rule the member vehicles of a "family" possess the same performance as regards mobility and protection. As a consequence of increasing the production of vehicles similar in design, at the same time a decrease in manufacturing costs is achieved.

From the beginning of the 1960's up to the present time, foreign countries have been continuing to build and furnish the military with postwar second-generation tanks.

A fairly complete picture of the achieved level and trends in future tank development can be obtained from an examination of the major combat performance characteristics of the main battle tanks adopted in the 1960's by the armies of those countries which are leaders in the area of development of armored equipment. These tanks include the following: M60A1 (United States), 48 tons (Figure 1.1.1); Chieftain* (Great Britain), 52 tons (Figure 1.1.2); AMX-30 (France), 36 tons (Figure 1.1.3); Leopard 1 (FRG), 40 tons (Figure 1.1.4). In spite of a considerable difference in weight, all of them are the main battle tanks for their countries' armies and are designed to perform the same missions. Table 1.1.1 lists the principal specifications and performance characteristics of foreign tanks.

All the listed tank models retain the traditional, so-called classic layout.

As regards new innovations, we should note the Chieftain tank, in which the driver assumes a semi-reclining position. This configuration is due to an endeavor to reduce overall tank height by shortening hull height, which makes it possible to reduce weight with given armor and to decrease probability of taking a hit on the battlefield.

The dimensions of today's main battle tanks vary across a fairly broad range. The M60A1 tank, for example, is the tallest (2,980 mm), while the AMX-30 is the shortest. The former is almost 700 mm taller than the latter. The Chieftain tank has the greatest hull length (7,650 mm), while the M60A1 tank has the greatest width (3,630 mm). The AMX-30 tank has the smallest dimensions: length -- 6,380 mm, width --3,110 mm.

* Here and henceforth these designations shall apply to the principal models of tanks of the designated types, that is, in this instance the Chieftain Mk2.

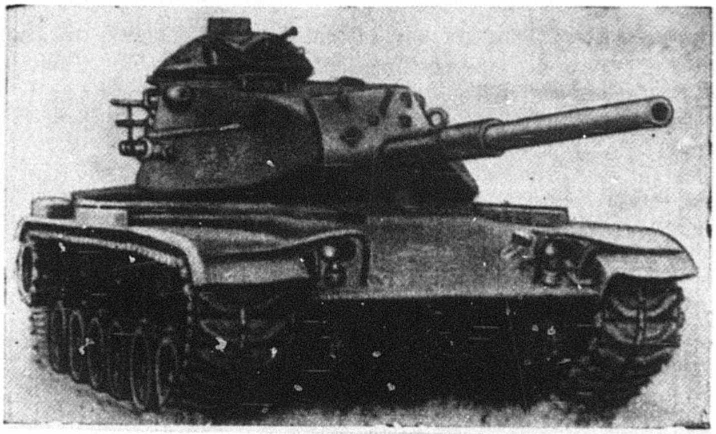


Figure 1.1.1. M60A1 Tank (United States)

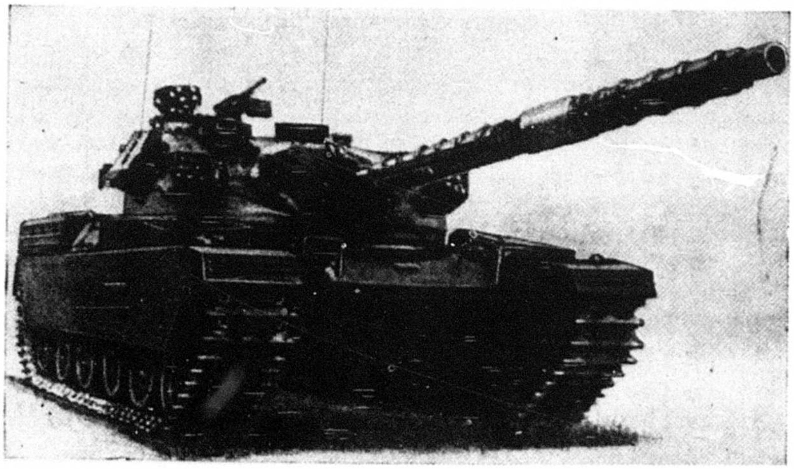


Figure 1.1.2. Chieftain Tank (Great Britain)

Figure 1.1.3. AMX-30 Tank (France)

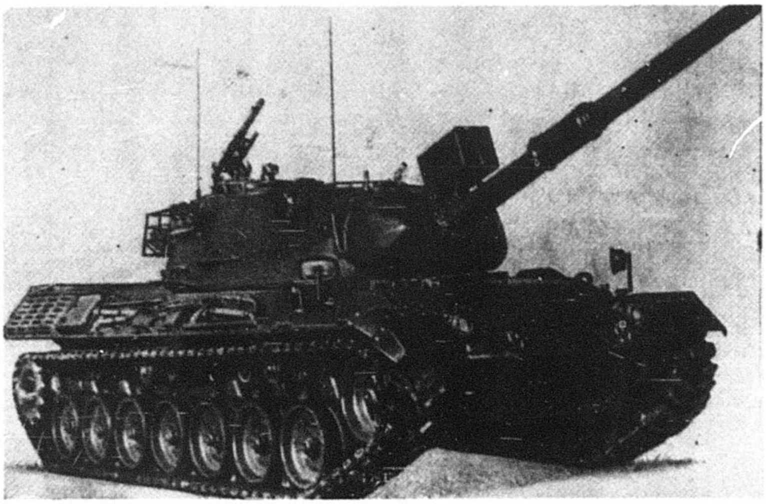


Figure 1.1.4. Leopard I Tank (FRG)

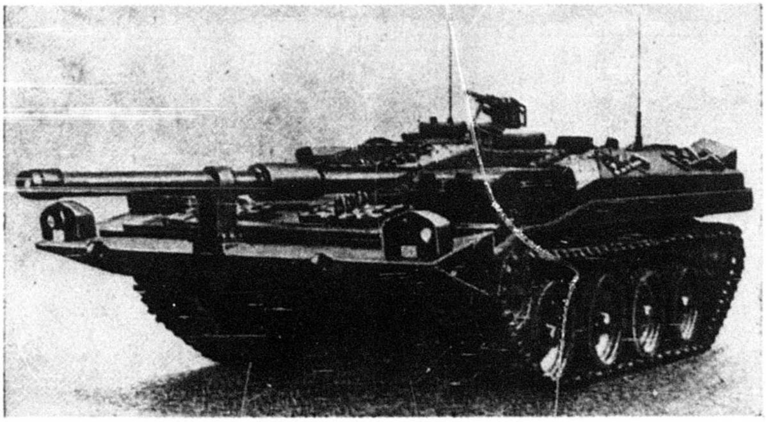


Figure 1.1.5. STRV103B Tank (Sweden)

The Chieftain tank is the heaviest, while the AMX-30 is the lightest. The difference between them is approximately 16 tons, which gives the AMX-30 tank considerable advantages in cross-country capability and transportability (ground, water and air). The Leopard 1 tank occupies an intermediate position in all these specifications.

The design of the Swedish STRV 103B tank is unique (Figure 1.1.5). It weighs 39 tons, and its 105 mm gun is mounted not in the turret but in the hull. This tank's turretless design is due to an endeavor to obtain a vehicle with thick armor protection at a lighter weight, since the turret accounts for up to 25 percent of the total weight of a tank. Mounting the tank's armament in the hull has made it possible to reduce the tank crew to three men, by employing automated loading.

Foreign experts, while noting the unique design of the STRV 103B tank, point to a serious deficiency of this layout -- the impossibility of delivering aimed fire

Table 1.1.1. Specifications and Performance Characteristics of Modern Foreign Tanks

Параметры 1	2 Основные боевые танки								Легкий танк „Шеридан" (США) 11
	M60A1 (США) 3	M60A2 (США) 4	„Леопард" 1 (ФРГ) 5	„Чифтен" (Англия) 6	AMX-30 (Франция) 7	Pz63 (Швейцария) 8	STRV103B (Швеция) 9	10 STB-6 (71) (Япония)	
Боевая масса, т 12	46,3	48	40	52	36	37	39	38	15,2
Экипаж, чел. 13	4	4	4	4	4	4	3	4	4
Калибр пушки, мм 14	105	152	105	120	105	105	105	105	152
Боекомплект 15	63	46 (в том числе 13 ПТУРС) (28)	60	53	56	52	50	50	30 (в том числе 10 ПТУРС) (46)
Пулеметы: 16									
спаренные 17	1—7,62	1—7,62	1—7,62	1—7,62	1—12,7	1—7,5	2—7,62	1—7,62	1—7,62
зенитные 18	1—12,7	1—12,7	1—7,62	1—7,62	1—7,62	1—7,5	1—7,62	1—12,7	1—12,7
Броневая защита 19	(31) Противоснарядная								Противопульная 47
Стабилизаторы вооружения 20	Устанавливаются при модернизации 26	29 Есть	Устанавливаются с модели A1 32	Есть 34	Установлены при модернизации 36	Установлены при модернизации 38	Нет 40	Есть 44	Есть 44
Средства точного определения дальности до цели 21	Оптический дальномер 27	Лазерный дальномер 30	Лазерный дальномер (с модели A4) (33)	35 Лазерный дальномер (с модели Мк3)	Устанавливают Л-Д при модернизации 37	Оптический дальномер 39	Лазерный дальномер (с модели 103B) (41)	Лазерный дальномер 45	Лазерный дальномер 45
Максимальная мощность двигателя, л. с. 22	750	750	830	700	720	660	240—490 (ГТД) (42)	720	335
Максимальная скорость, км/ч 23	48	48	64	41	65	50	50	60	68 (на плаву 5,6) (48)
Запас хода танка (по шоссе), км 24	500	450	600	400	500	475	340—400	475	500
Глубина преодолеваемого брода с ОПВТ, м 25	5	5	4	5	4	.	Плавающий (43)	4	Плавающий (43)

Key to Table 1.1.1 on preceding page:

1. Parameters
2. Main battle tanks
3. M60A1 (United States)
4. M60A2 (United States)
5. Leopard 1 (FRG)
6. Chieftain (Great Britain)
7. AMX-30 (France)
8. P68 (Switzerland)
9. STRV103B (Sweden)
10. STB-6 (74) (Japan)
11. Sheridan light tank (United States)
12. Combat weight, tons
13. Crew
14. Tank gun caliber, mm
15. Ammunition load
16. Machinegun
17. Coaxial
18. Antiaircraft
19. Armor protection
20. Weapon stabilizers
21. Means of precision target ranging
22. Maximum engine horsepower
23. Top speed, km/h
24. Tank range (highway), km
25. Fording depth with underwater operation equipment, meters
26. Installed during modernization
27. Optical range finder
28. 46 (including 13 ATGM)
29. Yes
30. Laser range finder
31. Shellproof
32. Installed beginning with model A1
33. Laser range finder (beginning with model A4)
34. Yes
35. Laser range finder (beginning with model Mk3)
36. Installed during modernization
37. Laser range finder installed during modernization
38. Installed during modernization
39. Optical range finder
40. No
41. Laser range finder (beginning with model 103B)
42. (Gas turbine engine)
43. Amphibious
44. Yes
45. Laser range finder
46. (including 10 ATGM)
47. Small-arms-proof
48. (5.6 afloat)

---

while rolling, since laying the gun for deflection is done with the tank hull, which greatly limits the effectiveness of utilization of this tank under combat conditions.

Let us examine the major combat performance characteristics of modern main battle tanks -- their firepower, armor (and special) protection and mobility, which will give us an idea of the attained level and trends in future tank development.

Firepower. Postwar second-generation main battle tanks adopted by the armies of the capitalist countries possess considerably greater firepower in comparison with earlier models. This has been achieved by carrying heavier guns with high muzzle velocities, by developing projectiles with great destructive effect on the target, and by equipping tanks with devices and mechanisms which increase accuracy and rate of fire.

Modern main battle tanks carry large caliber long-barrel guns as main armament. For example, the U.S. M60A1 tank, the Swiss P68 tank, the Japanese 74 (STB-6) tank, the Indian Vijayanta Mk1 tank, as well as the West German Leopard 1 tank carry the British 105 mm rifled gun, which was first employed on the British Centurion Mk9 tank. The French AMX-30 tank is armed with rifled-barrel systems of the same caliber, but of French design. The British Chieftain tank carries a 120 mm rifled gun.

According to information in the foreign press, subcaliber projectiles fired by the British 105 mm gun at a range of 1,000 meters, with a right-angled hit, can pierce steel armor approximately 300 mm thick. The high muzzle velocity of this gun's subcaliber projectiles, which reaches 1,475 mps, gives a high hit probability and considerable range.

Modern shaped-charge projectiles boast even greater armor defeating performance, piercing armor of a thickness of approximately 3.5-4.0 of the projectile caliber, regardless of range to the target.

Recently Britain has developed armor-piercing high explosive shells with a plastic explosive and squash head. The British hold these projectiles in high regard, especially due to their versatility, as a consequence of which their Chieftain tanks do not fire shaped-charge rounds. Shells of this type are also carried by certain other foreign tanks.

The U.S. M60A1 tank employs sabot projectiles, fin stabilized shaped-charge and armor piercing high explosive shells with plastic explosives, developed by the British for their 105 mm gun. In addition, the ammunition load carried by U.S. main battle tanks also include white phosphorus smoke shells, which are employed against enemy targets and for concealment.

The availability of shells of several types ensures the capability to score effective kills on diversified battlefield targets and give the tank gun great versatility, which is so essential to tanks.

Typical of the armament of main battle tanks of the armies of capitalist countries is a large number of rounds carried (up to 60), a figure obtained in spite of mounting large caliber guns on tanks. Improved accuracy of tank fire is achieved by employing vertical and horizontal plane gun stabilizers, by employing range finders which determine range to target, ballistic computers which automatically determine initial settings for firing (taking account of measured range, angular displacement of target, meteorological, topographic and ballistic conditions), employment of insulating gun jackets, etc. Accuracy of tank gun fire is sometimes improved by employing coaxial ranging machineguns, as is the case, for example, with the Chieftain tank, or even small-caliber guns, such as those carried for this purpose by the Swiss P68 tank. Obviously such a method of improving accuracy of tank fire increases the time required for readying the first round and gives away the tank's position.

Automation of the processes of preparing to fire, firing and fire control is one of the most important trends in development of tank armament.

In today's tanks the tank commander can rotate the turret from his control console. This enables him to take over fire control. In addition, the tank commander can aim and fire the tank's gun, utilizing a range finder (on the M60A1 tank, for example), if the gunner is disabled.

The experience of World War II and local wars in Korea, Vietnam, and the Near East demonstrated that troops should possess the capability to fight regardless of visibility. In connection with this, in order to ensure successful tank troops combat operations at night and in poor visibility, drivers, commanders and gunners of modern tanks are equipped with special gunsights and vision devices. This substantially increases tank combat utilization capabilities.

The level of fumes in a tank's fighting compartment from firing the tank's gun is reduced by the use of extraction devices to purge the barrel. Some tanks employ a spent casing ejection mechanism for this purpose, as well as to improve firing conditions and rate of fire (STRV103B and Centurion tanks), but combustible or semi-combustible cases are employed abroad for a more radical solution to the problem of gas level in the fighting compartment and its cluttering with spent shell cases.

The Leopard 1 tank is provided with a special exhaust ventilation system, in addition to an evacuator, to remove propellant gases released during firing of the tank gun and machinegun. A fan removes gases released during machinegun firing directly through holes in the mantlet or through a flexible hose, and removes gases by suction from the box under the tank gun's breech ring, into which the spent cases fall.

Auxiliary machineguns, including antiaircraft, are mounted on tanks to use against infantry, close-range antiaircraft weapons (rocket launchers, recoilless guns, antitank rifles, etc), lightly armored ground and slow-flying air targets.

Coaxial mounting of tank gun and machinegun is the usual practice. Frequently machineguns of various designation are mounted on commander's cupolas, which are mounted on a ball-bearing support for turning relative to the main turret. The M60A1, AMX-30 and Chieftain tanks, for example, carry commander's cupolas mounting machineguns. On the Leopard 1 tank an antiaircraft machinegun can be mounted on a ring mount over both the loader's and commander's hatch.

In order to increase the effectiveness of tank armament when firing at long range, the French AMX-13 light tanks carry, in addition to the main armament, several wire-guided antitank missiles carrying shaped charges with high armor-piercing capability.

In spite of success achieved in development of tank gun armament and in increasing accuracy of fire and force of projectile effect on the target, work is in progress in the United States, France and certain other capitalist countries to develop tank main armamment in the form of combined missile-gun armament capable of firing guided missiles (rockets) from the gun barrel as well as firing conventional projectiles.

In the opinion of a number of Western experts, success achieved in the area of rocketry, automatic control, remote control, and in the development of antitank guided missiles has already created certain preconditions for utilization of the latter as tank main armament. In their opinion, arming a tank with specially designed sophisticated tank guided missiles could mean a qualitative leap forward in boosting tank firepower.

The United States already has operational the Sheridan light amphibious reconnaissance tank (Figure 1.1.6) and a modification of the M60A1 main battle tank -- the M60A2 tank -- which carries as main armament a short-barreled 152 mm rifled gun which can fire conventional high explosive fragmentation shells and can also be used for firing infrared guided missiles through the barrel. This armament makes it possible, in the opinion of foreign experts, to employ the M60A2 tank as a reinforcement tank to hit enemy armored targets at long range.

Figure 1.1.6. Sheridan Tank (United States)

While not denying the expediency of employing guided missile weapons on tanks, the Americans are presently devoting principal attention to development of guns as main armament.

Armor and special protection. Today the defense has become densely saturated with various both close-range and long-range antitank weapons. In addition, the effectiveness of antitank weapons has substantially increased due to an increased accuracy of fire and greater force of projectile effect on the target. Fixed-wing aircraft and helicopter gunships are being utilized to an ever increasing extent against tanks.

Success achieved in the development of armor defeating weapons, and particularly antitank guided missiles, has resulted in the following: in the foreign press, especially since the Arab-Israeli war in October 1973, has frequently raised the question of the advisability of radically reducing tank armor protection which, in the opinion of the authors of such a plan, would be fully compensated by giving the tank greater mobility, and hence less vulnerability on the battlefield. Other experts, however, are of the opinion that there never have existed any tanks with unpierceable armor. There have always been on the battlefield means of killing tanks with fire. But the thicker a tank's armor, the fewer the weapons which can defeat a tank. Heavy armor substantially reduces the probability of tank kills by fire from various antitank weapons which may be employed on the battlefield, including tank guns. Thick armor places tanks in more favorable conditions in a fire fight with poorly armored enemy tanks, since in such an engagement decisive significance is assumed by the combination of firepower and armor protection.

The fact that armor is one of the most reliable means of protecting a tank's crew and internal equipment from the destructive and casualty-producing factors of a nuclear burst has also in the postwar years been considered an important

argument in favor of employing thick armor. Therefore throughout the entire period of development of main battle tanks, there has been observed a tendency toward increasing their armor protection. This situation has essentially continued up to the present day, and such well known main battle tanks of capitalist nation armies as the M60A1, Chieftain and others carry thick armor protection.

Foreign tanks developed in recent years -- the Leopard 2 (FRG) and XM1 (United States) -- according to published reports, are substantially superior in armor protection to the tanks which they are to replace.

The principal drawbacks to employing thick armor protection are connected with increasing a tank's weight, consequently decreasing mobility, cross-country capability, transportability and certain other performance characteristics. Therefore in the postwar years strengthening of the armor protection of tanks has proceeded not only in the direction of outright increasing the thickness of armor plate but also in the direction of steeply sloping the most critical armored surfaces, particularly frontal surfaces (slopes reach 60° and more on the M60A1 and Chieftain tanks) and differentiated distribution of armor thickness in relation to tank hit probability under combat conditions.

Optimal distribution of thickness of armored components with a predetermined weight can be achieved by casting armored components, which has found expression in turret designs, which up until recently* have been fabricated by casting for all main battle tanks.

The hulls of the majority of foreign tanks are fabricated of welded rolled plates; only the hulls of the U.S. M60A1 and Swiss P68 tanks are cast.

Today shellproof armor is made only of special armor alloy steels. Armor of light alloys is being used at the present time only to provide protection against small-arms fire.

The diversity of modern tank killing weapons creates additional difficulties in providing reliable protection simultaneously against armor-piercing kinetic projectiles and against shaped-charge ammunition, the effect of which on armor is based on different principles. In developing armor for a tank, designers also take into consideration the necessity of protecting the crew against penetrating radiation in the form of gamma radiation and a neutron flux. In connection with this many proposals are made pertaining to development of so-called composite or layered armor protection, made up of different materials.

In order to increase protection against shaped-charge projectiles, skirting plates began to be installed on the Centurion and Chieftain tanks, and subsequently on the modernized Leopard 1 tank as well. Obviously for this same reason Leopard 1 tanks began carrying welded turrets, which make it possible to provide so-called spaced armor protection. Provision of tank capability to operate for extended periods of

* Welded turrets began to be used on Leopard 1A3 tanks, produced since 1973, and on subsequent models of this tank, as well as on experimental models of the Leopard 2 and XM1 tanks.

time on terrain contaminated by radioactive substances and the necessity of protecting crew members from toxic chemical agents and bacteriological (biological) weapons dictated provision of modern tanks with a reliable airtight seal and filtering-ventilation units to purify the air reaching crew members and to establish an overpressure inside the tank, preventing contaminated substances from entering the tank together with air.

Mobility. All foreign military experts are unanimous in their view that the spatial scale, depth and pace of operations under conditions of a potential nuclear missile war demand a substantial increase in the mobility of tank troops and duration of tank troop operations without a halt. This has found expression in the development of tanks with higher top and average speeds.

The power to weight ratio of modern tanks is being increasingly more frequently increased in order to increase mobility. For example, postwar U.S. and British tanks (M26, Conqueror, Centurion, etc) boasted a power to weight ratio of approximately 12 horsepower per ton, today the M60 tank has a power to weight ratio of 16.2 horsepower per ton, while the Leopard 1 and AMX-30 tanks boast 20 horsepower per ton.

An increase in power-to-weight ratio up to the above figures has made it possible to obtain on the Leopard 1 and AMX-30 tanks top speeds on good roads up to 65 km/h, while employment of improved transmissions, control linkages and suspension systems permits high average speeds off roads as well.

Development of tank powerplants abroad is characterized by the adoption of diesel engines (in the USSR diesels have powered tanks since before the war).

Another typical trend in the development of tank powerplants is provision of a multi-fuel capability. Multi-fuel engines are presently powering the Chieftain, Leopard, AMX-30, STB-6 and certain other tanks.

In addition to the adoption of multi-fuel engines, a number of countries, particularly the United States, are engaged in intensive work on development of gas turbine engines for tanks, although initial models at the present time have poorer fuel economy than piston engines.

The attention being devoted to gas turbine engines is due to the fact that they are lighter and smaller than piston engines, and this offers definite advantages in developing a small powerplant. In addition, foreign military experts believe that the tractive performance of a gas turbine engine, which is well suited to a tank, makes it possible to simplify transmission design and to make it smaller, which on the whole makes it possible additionally to reduce the volume of the engine and transmission compartment. This space can be used for fuel stowage and can to a certain degree compensate for the engine's poor economy.

Gas turbine engines can run on various fuels and are easy to start. At the present time they are being installed only on experimental models of foreign tanks (for example, on a special model based on a Conqueror tank chassis). The Swedish STRV103B tank carries a gas turbine engine mounted parallel to the main multi-fuel piston engine and is fired up to assist it only when the power required by the operating conditions is greater than the horsepower of the main engine. The U.S. XM 1 tank has a gas turbine main engine.

We should emphasize certain powerplant features which are common to the latest models of U.S. and FRG tanks, which reflect a focus on the possibility of developing heat-dissipating devices for intensive mixing (cooling) of engine exhaust gases with the cooling system airflow prior to being expelled from the tank.

One way to increase tank range, other than adopting engines with low fuel consumption, is to increase fuel carrying capacity.

In spite of the fact that the endeavor to reduce tank weight results in maximum reduction of hull interior volume, the urgent need to boost tank range dictated an increase in the fuel supply carried inside a tank. For example, internal fuel tank capacity on the M60A1 tank is 1,470 liters, 985 liters on the Leopard 1, and 950 liters on the AMX-30. As a result, the range of the most recent models of foreign tanks exceeds 500 km on a surfaced highway.

Improved mobility of modern tanks is also achieved by employing better transmissions, control linkages, hull suspension systems, and improved visibility. Modern tanks employ various 5-7 gear mechanical transmissions, and hydromechanical transmissions.

Hydromechanical transmissions with hydrodynamic torque converters are widely employed on tracked and wheeled armored vehicles. The Swedish STRV103B, the Swiss P68 tank, and the West German Marder armored personnel carrier employ stepless steering mechanisms in order to improve ease of handling; change in track speed required to execute a turn is achieved with the aid of controlled hydraulic transfer units, powered by the engine parallel to the main flow of power to the transmission.

Realization of a tank's tractive and dynamic characteristics, provided by the powerplant and transmission, depends to a large degree on the performance of the control linkages. Hydraulic servo links are in quite widespread use today, with control work performed almost entirely on the energy provided by special sources. The Chieftain tank shifts gears by electric-powered linkage. On the Leopard tank the hydraulic-linkage slide valves feature electromagnetic remote control.

The steering controls on some tanks are similar to automotive and aircraft controls, that is, in the form of a steering wheel (M60A1 and Leopard 1 tanks).

An important role in achieving a high average tank speed off roads is played by the quality of the suspension systems, and therefore considerable attention is currently being focused on improving them.

In comparison with the other main tank system groups, the track drive is the shortest-lived. This is due to the extremely severe operating conditions of such drive components as the track links and meshing points. At the present time two types of track links are employed: open metal and ring-type rubber-metal (silent block).

Excellent tank cross-country capability is obtained with a small specific ground pressure and good track-soil adhesion. This is achieved by employing wide tracks with effective lugs. The experience of the last war substantiates the low specific ground pressure achieved by the Leopard 1 and AMX-30 tanks (0.77 kg/cm^2 for the AMX-30).

Great importance has always been attached to ability of tanks to cross rivers. This is particularly important under present-day conditions, since combat operations should be conducted at a rapid pace. Modern tanks can cross rivers without employing unwieldy crossing equipment -- wading, and afloat. A tightly-sealed hull and effective turret race seals enable tanks to cross deep fords with little preparation.

Underwater tank operating capability at a depth of 4-5 meters is today considered practically a mandatory requirement on modern tanks. These requirements are met by the M60A1, Leopard 1, AMX-30 and other tanks. In the Soviet Union submerged tank operation was tested as early as before World War II.

In order to cross rivers afloat under its own power, a tank should possess buoyancy and water propulsion capability. For this purpose a number of tanks (Centurion, SRTV103B) are equipped with detachable screens which increase their displacement. Either the tank's tracks or special detachable propellers powered off the tank's drive sprockets are employed as water propulsion devices.

Modern tanks employ various navigation gear for determining position in the field -- from a simple directional gyro with speedometer to highly complex computer-equipped course indicators and automatic course plotters.

The Leopard 1A3, AMX-30 and P68 tanks employ computers for continuous determination of the tank's topographic coordinates and angle of movement. In the Swedish ANS-100 navigation system, results are gauge-displayed; in the German Teldix and Canadian LNS systems, the track covered by the tank is additionally recorded by an automatic recording stylus or indicated on a map by an illuminated arrow.

U.S. and British tanks, in addition to a course plotting computer, employ a course indicator showing the shortest route to the selected destination. The gauges continuously display the tank's current coordinates, distance to destination, the tank's course angle and bearing to destination. The tank's route of movement is recorded on a map by the automatic course plotter.

Reliability has become extremely important for today's tank. We should note that tank reliability is defined as its capability to operate continuously, in conformity with its combat performance characteristics, without repairs, complicated adjustments and replacement of parts and assemblies if they are not specified as part of routine servicing of this equipment.

Modern combat operations demand that a tank crew remain in the tank for extended periods of time with fully closed hatches. At the same time the endeavor to achieve a compact layout, dictated by demands of reducing weight, decreasing size and strengthening armor protection have resulted in extremely small tank interior spaces, while the necessity of protecting the crew against the various casualty-producing elements of the nuclear burst has required that vehicles be fully airtight. If to this we add the fact that the fighting compartment and driving compartment become filled with propellant gases during firing, one gains a picture of the difficult conditions in which a tank crew will find itself, especially at high outside air temperatures.

In connection with this there arose the necessity of equipping tanks with ventilation and air conditioning units which would ensure the interior air a specified degree of purity, temperature and humidity (microclimate).

In conclusion it is important to stress that as armored equipment becomes more sophisticated, the design of combat vehicles becomes more complex, and their cost increases. According to information published abroad, for example, at the end of World War II the U.S. M4A4 main battle tank (Sherman) cost approximately 55,000 dollars, while the M48 tank cost 156,000 dollars in 1958, the M60A1 tank cost 220,000 dollars in 1971, and the cost of the XM 1 main battle tank, produced in quantity, will exceed 500,000 dollars.

2. Future Evolution of Tanks and Their Performance Characteristics

By the mid-1970's the process of saturating forces with postwar second-generation tanks, that is, the M60A1, Chieftain, Leopard 1, and AMX-30 tanks, developed at the beginning of the 1960's, was completed in the major capitalist countries. Modernization is of great importance in improving performance characteristics, alongside the normal process of tank development, involving systematic development of new models for the immediate and more distant future.

Tank modernization consists essentially in the following: in connection with the fact that one and the same tank has been in production and on the line for an extended period of time, models of subsequent series, in order to improve their combat effectiveness, are equipped with improved instrumentation, mechanisms, systems and equipment. The performance characteristics of tanks of subsequent series prove to be better, which makes tanks of one and the same type unequal from the standpoint of combat capability and leads to destandardization in respect to their equipment.

In order to correct this deficiency, a number of countries are "boosting" older tank models to the level of more recent models. As is indicated by the development of the different models of the Leopard 1, M60A1, Chieftain and other tanks, principal attention in improving the performance characteristics of main battle tanks in the process of their modernization is focused on increasing firepower by improving accuracy of tank fire and increasing rate of fire. In connection with this, tanks are equipped with increasingly more sophisticated means of automating the processes of preparing for firing and firing, which increase first-round hit probability at all ranges. On those postwar second-generation tank models, on the first series of which gun stabilizers, range finders or ballistic computers were not installed, they are installed on later series (models), while less sophisticated range finders and mechanical computers are replaced with laser and electronic equipment respectively.

Only on the M60A2 tank, which constitutes one direction of development of the M60 tank, is boosting firepower based on employment of a combined gun-launcher, which makes it possible to use a gun of moderate ballistics (but large caliber) to fire both conventional projectiles and missiles.

Strengthening of armor protection when modernizing postwar second-generation tanks is limited by the complexity of altering a vehicle's design and as a rule is performed only on those vehicles which possess certain reserve in their power-to-weight ratio, since these measures involve increasing a tank's weight, and this can lead to diminished mobility. Therefore only anti-shaped-charge skirting plates were added to the Leopard 1A1, while turret armor was strengthened on the Leopard 1A2 and Leopard 1A3.

Improving mobility through modernization is a very difficult task, since this usually requires increasing engine horsepower, which leads to substantial changes in tank hull design. Therefore improved mobility on these models is achieved as a rule not by increasing the tank's power-to-weight ratio but by furnishing the tank with equipment for deep fording without a halt, by providing the driver with improved night vision devices, etc.

As a rule, modernization of each new model provides further improvement in operational reliability of the tank's machinery and mechanisms.

Development of future main battle tanks. Following failure of the joint U.S.-West German development of a main battle tank for the 1970's (MBT-70), these countries went their own separate ways in designing technically simpler and consequently less expensive tanks than the MBT-70.

In 1972 the United States commenced work on the new XM1 tank, which the Pentagon plans to use as a replacement to the M60 series tanks. The well known automotive companies Chrysler and General Motors, which have long specialized in the area of building tanks, proceeded with development of this new tank on a competitive basis, working on the same specifications and performance. Experimental models of the tanks developed by these two companies underwent factory testing in 1975, and competitive tests to determine the better model began in the spring of 1976.

The two tanks have much in common: a welded hull with highly-sloped glacis plate, a welded turret carrying a 105 mm rifled gun, and layered armor protection. Both tanks carry a four-man crew and weigh approximately 53 tons. The tanks carry a fire control system which includes horizontal and vertical gun stabilization, a laser gunsight-range finder, electronic ballistic computer, and gunsight with stabilized line of sight.

As auxiliary armament the XM1 tank carries a 7.62 mm machinegun coaxial with the main armament; in the future this machinegun is to be replaced with a 20-30 mm gun; a 12.7 mm antiaircraft machinegun mounted by the commander's position, and a 7.62 mm machinegun center-pivot mounted by the loader's position.

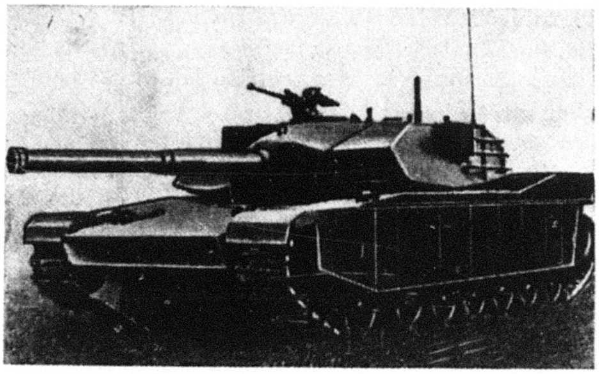


Figure 1.1.7. XM1 Tank (United States)

In order to increase tank battlefield survivability, on both models of the XM1 tank ammunition and fuel are stored in isolated armored compartments. The XM1

tank, due to elimination of the commander's cupola and compression of the hull, is considerably less than the M60 series tanks in height.

Both test models of the XM 1 tank are powered by 1,500 horsepower engines: the General Motors tank is powered by a diesel engine, while the Chrysler tank is powered by an AGT-1500 gas turbine engine. Both models employ the same hydro-mechanical transmission -- an Allison X-1100, which has four speeds forward and two reverse. The continuous steering gear, with disengaged gearbox, enables the tank to turn with the tracks rotating in opposite directions.

It is believed that the tank's high power-to-weight ratio (approximately 30 horsepower per ton), with improved transmission and suspension system, will enable both models to attain a top speed of 70 km/h and an average off-road speed of 40-50 km/h.

According to reports in the U.S. press, in the spring of 1977, as a result of comparative tests on the submitted versions of the XM-1 tank, the nod was given to the Chrysler version (Figure 1.1.7), which was assigned the designation Abrams. Initiation of series production was targeted for 1979.

In the FRG development of new tanks is proceeding at a very rapid pace. By 1976 factory and field testing was completed on experimental versions of the Leopard 2 main battle tank, which was to replace the obsolete U.S.-made M48A2 tanks which the Bundeswehr was still using .

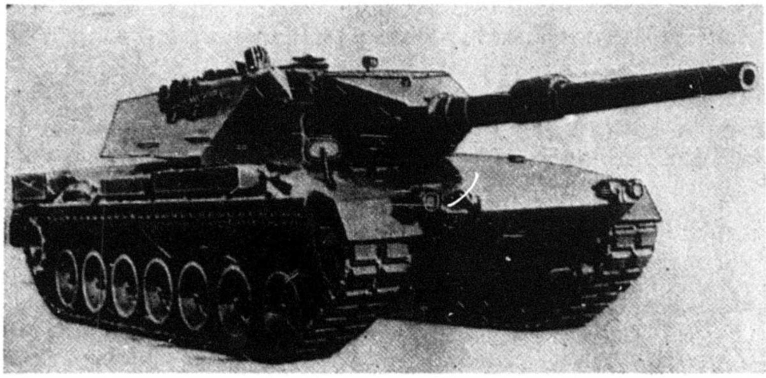


Figure 1.1.8. Leopard 2 Tank (FRG), With Skirting Plate Removed

---

The Leopard 2 tank (Figure 1.1.8) has a traditional layout, with the engine-transmission compartment positioned aft and carrying a four-man crew. The tank's hull and turret are welded.

This tank was developed with employment of improved assemblies and components of the Leopard 1 models, as well as satisfactorily performing gear developed during the joint project, with the United States, on a version of the MBT-70 tank -- the KP70 tank.

The tank's main armament will be a 105 mm or 120 mm smoothbore gun, which is currently undergoing comparative tests with this aim in mind.

The Leopard 2 tank employs a new fire control system, which includes a laser gunsight-range finder, electronic ballistic computer, vertical and horizontal gun stabilizer, passive infrared gunsights and vision devices. Weighing about 55 tons, the Leopard 2 has thicker armor protection than the Leopard 1. It is powered by a multi-fuel 1500 horsepower diesel engine, which provides the tank with high speed and acceleration.

An improved version of this tank has been developed on the basis of testing of versions of the Leopard 2 tank; the improved model is designated the Leopard 2AV. The principal difference between the Leopard 2AV and the Leopard 2 tank is employment of a turret of new design with reinforced multilayered armor, as well as storage of fuel tanks and ammunition in explosion-safe containers.

In 1976 the Leopard 2AV tank was being built in two versions. One tank, with a T-20 turret, carrying a 120 mm smoothbore gun and an improved fire control system, was being built by the West German company AEG-Telefunken, while the other, with a T-19 turret, carrying a 105 mm rifled gun and fire control system, was built by the U.S. firm of Hughes. On the basis of tests, preference was given to the 120 mm smoothbore gun.

A Leopard 2AV tank with the T-19 turret was tested at proving grounds in the United States for the purpose of comparing its performance with U.S. experimental versions of the XM1 tank. In these tests its average speed proved out at 55 km/h on rough terrain and 68 km/h on roads.

According to published information, work on future tanks is also in progress in France and Japan; French experts, just as in many other capitalist countries, reached the conclusion that tanks in the immediate future should carry gun, not missile-gun armament. Therefore a 120 mm smoothbore gun was selected for France's new tank, and new ammunition is being developed.

Chapter 2. SELF-PROPELLED ARTILLERY

Self-propelled artillery first appeared in the armament of armies considerably later than tanks, in the process of development of armored equipment and designation of combat vehicles to perform narrower, more specialized missions. For this reason their armament is not as versatile (as regards performance characteristics and capabilities) as tank armament.

In the postwar period, in connection with the necessity of ensuring a rapid rate of troop advance, self-propelled guns, designed to provide fire support to ground forces combat units, experienced extensive development in the armies of a number of countries, especially the U.S. Army.

This category of armored fighting vehicles performs a totally different function than the self-propelled guns employed in the Soviet Army. The self-propelled guns developed in the USSR in the latter half of the Great Patriotic War were mounted on tanks (light, medium and heavy), by replacing the rotating turret with a fixed armored housing, in which would be mounted a gun of a large caliber than in the turret of the corresponding tank. This made it possible under conditions of wartime, without decreasing the rate of production of armored equipment, to obtain for the army armored fighting vehicles possessing greater firepower than the tanks on which they were based.

Following were the principal missions of the various types of Soviet self-propelled artillery of that time:

light -- killing personnel and weapons, exposed and lightly sheltered;

medium -- destroying tanks and assault guns;

heavy -- destroying and neutralizing permanent pillboxes, earth-and-timber emplacements, engaging artillery, repulsing attacking tanks and assault guns.

Soviet self-propelled guns for the most part employed direct fire from brief halts. They were equipped with panoramic sights for fire from indirect positions.

Today's self-propelled artillery is assigned the mission of providing direct support to ground troop units combat operations. They are used because even under conditions of nuclear missile warfare, artillery support is frequently needed for successful operations by tank and motorized rifle (motorized infantry) units to penetrate a defense and in the course of combat operations. For this mission

brigades, divisions and corps of the armies of the United States, FRG, France and other countries contain artillery units armed with self-propelled guns, which constitute lightly-armored mobile tracked vehicles carrying howitzers or guns. As a rule they will deliver group fire from indirect fire positions.

In conformity with the missions performed, self-propelled artillery armament should boast a substantial range, the capability to kill targets over large areas, as well as good fire maneuverability (in range and laterally).

As practical experience indicates, the armament of self-propelled guns up to 150 mm can be mounted in a fully-rotating enclosed turret. Some self-propelled guns are armed with machineguns, which have the mission of engaging air and ground targets. Normally they are mounted externally on the turret. Antinuclear protection is provided by sealing the hull and turret (when a turret is present) and providing filter-ventilation units designed to protect the crew against radioactive dust and toxic chemical agents.

U.S. Army officials, attaching great importance to combat vehicles of this category, at the beginning of the 1960's adopted the M108, M109, M107, and M110 self-propelled guns.

The M108 and M109 self-propelled howitzers (Figure 1.2.1), which are similar in design, extensively employ assemblies from the M113 armored personnel carrier and carry 105 mm and 155 mm howitzers respectfully.

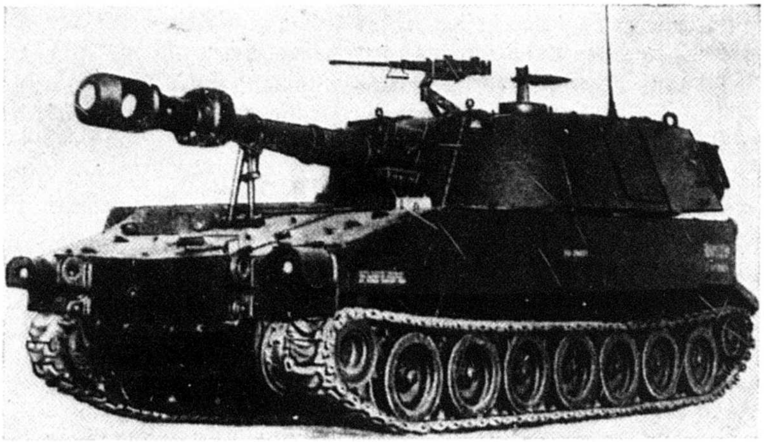


Figure 1.2.1. M109 Self-Propelled Howitzer (United States)

The armament is mounted in fully-rotating turrets, and the small arms-defeating armor plating on the hull and turret is of aluminum alloys, which made it possible to give the vehicles float capability with the aid of inflatable rubberized floats. A speed of up to 5 km/h afloat is achieved with the aid of the vehicle's regular tracks. These self-propelled howitzers carry a 5-man crew.

The M109 self-propelled howitzer, which carries more powerful armament than the M108, at the beginning of the 1970's replaced the latter in U.S. mechanized and armored divisions.

In addition to the standard high explosive fragmentation shells, low-yield nuclear shells were developed for the 155 mm howitzer. The vehicle carries a full ammunition supply of 28 rounds. Maximum vehicle speed on dry ground is 56 kh/h, and the vehicle weighs 26 tons.

The M107 self-propelled gun (175 mm) and M110 self-propelled howitzer (203.2 mm), pictured in figures 1.2.2 and 1.2.3, are mounted on the same special chassis. The artillery systems are mounted exposed on the chassis in the rear portion of the hull and have a limited, 60 degree traverse. The hull is welded of armor steel plates of various thickness and is divided by bulkheads into the following compartments: driving, engine and transmission, located in the forward part of the hull, to the left and right respectively, and the fighting compartment, positioned to the rear of the hull. The vehicle carries a five-man crew (a driver, who is also gun commander, two gunners, and two loaders). These vehicles have a top speed of 55 km/h. The drive sprockets are forward, and the idler wheels also perform the function of sprung road wheels.

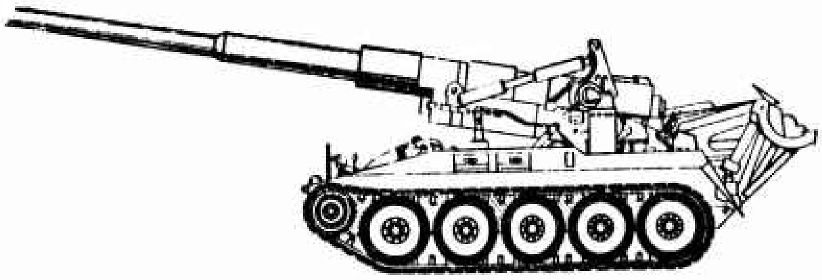


Figure 1.2.2. M107 Self-Propelled Gun (United States)

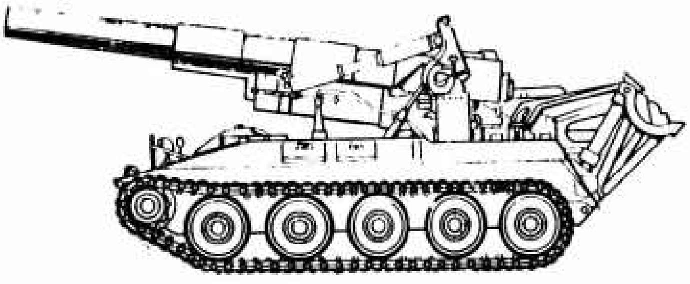


Figure 1.2.3. M110 Self-Propelled Howitzer (United States)

According to published reports, the M107 self-propelled gun and M110 self-propelled howitzer (weight 28 tons) can be airlifted by two aircraft: the chassis is transported in one aircraft and the gun proper in the other. The 175 mm gun carries only high explosive fragmentation shells. Maximum range of fire is 32.6 km. The M110 fires a high explosive fragmentation shell and a low-yield nuclear shell. Maximum range of fire is 17 km.

The M107 and M110 carry only two rounds on the self-propelled gun proper, while the remainder of the ammunition supply is carried by an auxiliary transport vehicle.

The M107, M109 and M110 are extensively employed not only in the U.S. Army but also in the armies of the FRG, Great Britain, Italy, the Netherlands, Norway, Israel, etc.

The British Army adopted in 1963 the Abbot 105 mm self-propelled gun. It is similar in design to the M109. It is based on a British FV432 armored personnel carrier chassis (Trojan), features a fully armored hull, a rotating turret, and is capable of crossing rivers afloat. This unit fires armor piercing, high explosive fragmentation, and smoke shells. Maximum range of fire is 18.5 km. The vehicle has a maximum speed of 47 km/h on land and 5.6 km/h on water. It carries a four-man crew and weighs 17 tons.

In the French Army the artillery regiments of mechanized divisions also contain self-propelled artillery. A 105 mm self-propelled howitzer, based on the AMX-13 light tank, is similar in design to the U.S. M108 and M109. The vehicle is fully armored. The howitzer is mounted in a fully-rotating turret (prior to modernization, effected in 1962, the howitzer was mounted in a fixed turret-like structure).

The design of the French 155 mm self-propelled howitzer is reminiscent of the M107 and M110. It was developed in 1962, on the modified chassis of an AMX-13 light tank. The weapon, which is a modernized upper part of the M50 155 mm field howitzer, is mounted exposed, without armor cover, on the rear of the vehicle.

In Israel the L-33 self-propelled howitzer was developed on the chassis of the U.S. M4A3 Sherman tank, which was built during World War II. The L-33 was used by the Israelis in the October War of 1973 for artillery support. This self-propelled unit carries a French M50 155 mm howitzer mounted in a fully armored enclosed hull. A 7.62 mm machinegun is mounted in a rotating sub-turret.

In recent years self-propelled artillery for this role has been evolving toward increased firepower, achieved in the course of modernization, and development of new models based on main battle tanks.

Increasing the firepower of self-propelled artillery during modernization is achieved by increasing range and effectiveness of projectiles on the target. Increased range in turn is achieved by lengthening the barrel, increasing propellant charge, improving the ballistics of the artillery system and projectile, and by employing rocket-assisted projectiles.

In modernizing the M109 155 mm self-propelled howitzer, for example, the barrel was lengthened by 2.44 m, which made it possible to increase range when firing a high explosive fragmentation round from 14.6 to 18.1 km (following modernization the self-propelled howitzer was redesignated the M109A1).

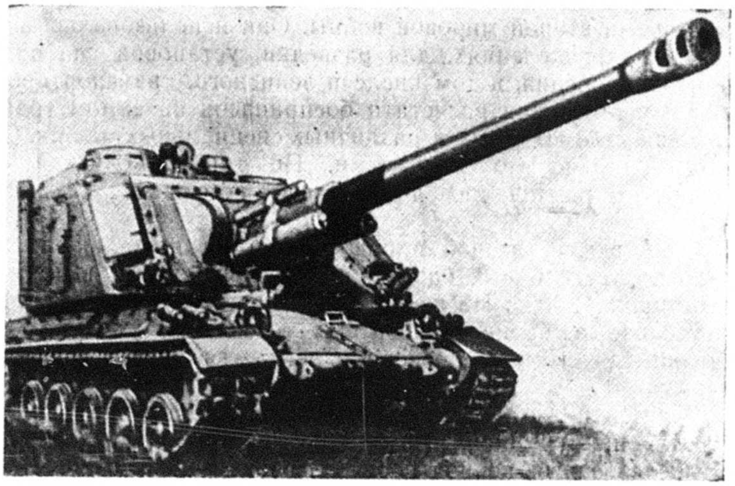
The barrel of the M110 203.2 mm self-propelled howitzer (following modernization redesignated M110E2) was lengthened by 2.74 m, which made it possible to increase range, when firing a high explosive round, from 17 to 22 km, and to 30 km when firing a rocket-assisted projectile.

For the purpose of standardization of combat equipment employed by ground forces combined units, as well as to achieve mobility and protection equal to tanks, a number of Western countries began developing self-propelled artillery based on main battle tanks.

Figure 1.2.4. 155GCT Self-Propelled Gun (France)

France, for example, developed the 155GCT 155 mm self-propelled gun based on the AMX-30 tank (Figure 1.2.4); the 155GCT was tested in 1973. Its gun is mounted in a fully-rotating armored turret. A 7.62 mm (or 12.7 mm) machinegun is mounted on the turret roof, over the loader's hatch. One feature of this self-propelled gun is the employment of automatic loading and fire control system, which provides a rate of fire capability of up to 8 rounds per minute. The fire control system can put the gun on the target both in direct fire and indirect fire situations. The vehicle carries a four-man crew. Published reports stated that the 155GCT self-propelled gun is to replace in the French Army the 155 mm self-propelled howitzer based on the AMX-13 tank.

The Swedish Army has adopted the VK155 155 mm self-propelled gun, based on the STRV103B tank. The gun is mounted exposed on the rear of the vehicle between fixed turret-like structures on the left and right. Automatic loading makes it possible to deliver both automatic fire and single shot fire. The vehicle carries a five-man crew.



Chapter 3. ARMORED PERSONNEL CARRIERS AND INFANTRY COMBAT VEHICLES

1. Tracked Armored Personnel Carriers and Infantry Combat Vehicles

Much attention has been devoted in the armies of the capitalist countries in the postwar years to the development of armored personnel carriers (APC) and especially infantry combat vehicles (ICV). Although tank design also exerts considerable influence on the development of vehicles of this category, development of a number of characteristics of APC and ICV is proceeding in an independent direction, proceeding from the role and features of their combat employment. Armored personnel carriers were fairly extensively utilized in World War II. They were employed in motorized infantry units, for reconnaissance, for mounting various armament, including antiaircraft guns, for transporting guns and accommodating gun crew and ammunition on the carrier proper, and as staff and various specialized vehicles. They were entirely open on top. Armored personnel carriers were divided into wheeled, tracked, and half-tracked types.

During World War II the United States built a total of 41,000 half-tracked armored personnel carriers.* The Wehrmacht was also equipped with light and medium half-tracked armored personnel carriers. Great Britain built for the most part light tracked armored personnel carriers.

During the Great Patriotic War the Soviet Army used tracked and half-tracked armored personnel carriers.

In the postwar period, in connection with the increased pace of combat operations, armored personnel carriers began to be quite extensively employed in motorized rifle (motorized infantry) troops, not only to transport infantry but also for combat mounted.

Armored personnel carriers of only two types have been employed in quantity since World War II: wheeled and tracked. Half-tracked armored personnel carriers are no longer being built, although activities abroad in this area are continuing, as a consequence of the tempting possibility of combining the positive characteristics of both types.

---
* See ZARUBEZHNOYE VOYENNOYE OBOZRENIYE, No 8, 1974.

Simultaneous employment of wheeled and tracked armored personnel carriers in the armies of the world is dictated by the following factors: track drive offers simplicity of vehicle overall design, excellent terrain capability under various conditions, and a high degree of battlefield survivability. But a tracked vehicle is quite inferior to a wheeled vehicle in terms of service life and efficiency, which affects fuel consumption, vehicle range, and powerplant horsepower requirements.

In addition, a wheeled vehicle operates noiselessly and can run on hard-surface roads without damaging them. Another important factor in employing wheels rather than tracks on an APC is the existence of an extensive production base -- the automotive industry.

Competition between tracked and wheeled systems for utilization on combat vehicles of this category led to a reduction in the deficiencies characteristic of both types, without giving one type total superiority over the other.

The development of combined rubber-metal track links has made it possible substantially to extend their service life and improve their efficiency at high speeds.

At the same time the employment of APCs with multiple driving wheels and development of tires of special design have made it possible to improve the cross-country capability of wheeled vehicles, while the development of bulletproof tires has increased their survivability in combat conditions.

Substantial changes in the design of armored personnel carriers made in the postwar years were a consequence of the potential employment of weapons of mass destruction, which dictated reexamination of performance requirements on all armored equipment.

According to current views, armored personnel carriers should be capable of travel across terrain with radioactive, chemical and bacteriological contamination, that is, they should be fully armored, sealed, equipped with an antinuclear protection system and an air filtration-ventilation system, effectively diminishing the effect of the casualty-producing elements of weapons of mass destruction on personnel.

In order to increase troop mobility, it is desirable that armored personnel carriers be amphibious and air-transportable (the latter requirement limits their size and weight).

Armored personnel carriers employed today in motorized rifle (motorized infantry) troops are usually built to accommodate a squad.

In the past it was considered that the APC was intended only to transport infantry to the battlefield, while combat proper was conducted only in dismounted combat formations, while today in a number of combat situations doctrine calls for infantry to fight mounted on personnel carriers, which therefore should be of appropriate design and construction.

Infantry combat vehicles represent a further stage in the evolution of armored personnel carriers. ICVs are a qualitatively new weapon for motorized rifle (motorized infantry) units -- the principal infantry means of combat and transportation under present-day conditions. They give infantry the requisite mobility and

protection, increase infantry fire capabilities and ensure close coordination with tanks.

Obviously one should not view the ICV as an independent weapon, as some kind of light tank for motorized rifle troops. The tank and ICV are partner vehicles, complementing one another and working in close cooperation in the performance of combat missions.

Possessing a good field of view and diversified personal weapons, infantry equipped with ICVs, fighting both dismounted and mounted, can do a better job than tank crews in hitting mass close-combat antitank weapons (antitank rifles and grenade/rocket launchers). The fact that the ICV carries mounted weapons in the form of guns and ATGM enables the vehicles' crews to hit armored targets, to provide fire support to a dismounted assault force, and if necessary to deliver fire on tanks and helicopters.

At the same time, employment of high-mobility vehicles to transport infantry to and on the battlefield will enable infantry to conduct dynamic, highly-mobile actions under the most diversified conditions.

We should emphasize that the birth and development of the ICV does not eliminate the future development and retention of armored personnel carriers. Under present-day conditions the APC should be viewed as a mass-use version of the ICV, with limited capability for infantry to deliver fire mounted and for teamwork with tanks. Retention of the APC is dictated by the mass character of modern armies, by the fairly high cost of an ICV, and by the specific features of a theater.

In the view of foreign military experts, track drive is more preferable for an ICV: it possesses important advantages of layout and has much greater battlefield survivability. A wheeled system is employed on those combat vehicles which require first and foremost higher speed, greater range, and quiet operation.

Both tracked and wheeled armored personnel carriers are being produced abroad.

At the present time APCs are employed:

as a means of transport and weapon of motorized (motorized infantry) units, and in a number of instances also as a mass-use and comparatively cheap ICV;

for conduct of reconnaissance;

as a platform for various weapons;

as command vehicles, control and communications vehicles, ambulance, transport vehicles, etc.

In 1958 the United States began producing the M113 tracked amphibious armored personnel carrier, designed to carry an infantry squad on the battlefield. Subsequently more than 40,000* combat vehicles of various roles have been built based on the M113 APC. At the present time they are being used by the armies of almost 30 countries, while in some countries such vehicles are being built under U.S. license.

* See ZARUBEZHNOYE VOYENNOYE OBOZRENIYE, No 8, 1974.

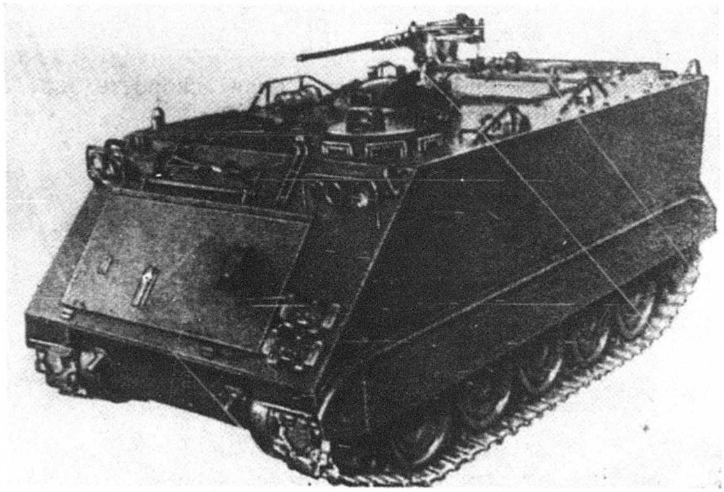


Figure 1.3.1. M113A1 Armored Personnel Carrier (United States).

Foreign experts note the following features of the M113 armored personnel carrier: relatively light weight (10.4 tons), as a result of employing aluminum alloy armor; good cross-country performance (it is amphibious, with a ground pressure of 0.51 kg/cm^2); large load capacity; simplicity of construction (hence the vehicle's low cost and ease of repair when it breaks down).

A large "family" of vehicles was developed, based on the M113 armored personnel carrier: a mobile command post, a 107 mm mortar carrier, flame thrower, carriers for the Mauler antiaircraft missile system, the Lynx command and scout vehicle, etc.

After modernization, consisting in installing a diesel engine with a new hydro-mechanical transmission, this armored personnel carrier was redesignated the M113A1 (Figure 1.3.1). Addition of the diesel engine increased the vehicle's range to 500 km.

Combat experience with the M113A1 APC in Southeast Asia showed the need to make a number of improvements which increased its combat effectiveness. In order to improve cross-country performance, the M113A1 APC carries self-recovery gear. It is air-transportable and can be dropped by parachute.

The M114 tracked armored personnel carrier (redesignated M114A1 following modernization) has been in use since 1960 and is employed by the U.S. Army as a scout and command vehicle. It can accommodate four persons. Combat weight is approximately 6 tons. It is armed with a 12.7 mm machinegun mounted on a ring mount on the fixed commander's cupola, and a 7.62 mm machinegun on a saddle pivot mount on the hull roof. It carries aluminum alloy armor for protection against small-arms fire. Maximum speed on land is 64 km/h, and on water -- 6 km/h (with tracks assisting as paddles).

Work has been in progress for quite some time now in the United States on development of the XM723 amphibious ICV (Figure 1.3.2), weighing 18 tons and armed with a small-caliber gun. It is intended to fight in the general order of battle with the

main battle tanks. Its frontal armor should provide protection against a 23 mm projectile at a range of 300 meters, side and rear armor should defeat 14.5 mm bullets at a range of 300 meters, and the roof armor should protect against 155 mm shell fragments in a radius of 10 meters from the burst point.

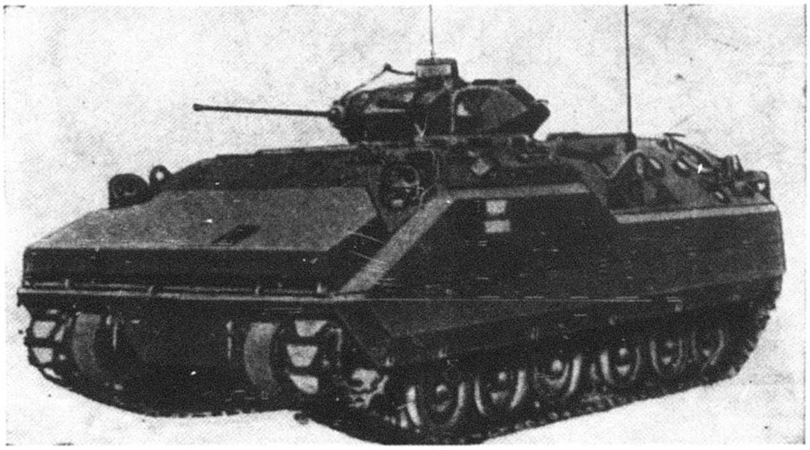


Figure 1.3.2. XM723 Infantry Combat Vehicle (United States)

According to published reports, one obstacle impeding the development of an ICV for the U.S. Army is the vehicle's high cost, which is estimated at 123,000 dollars for this version (the M113 APC costs about 30,000 dollars).

In the FRG, Bundeswehr officials, in contrast to a number of their NATO bloc allies, are of the view that with the aid of lightly armored vehicles it is possible not only to deliver infantry to the battlefield but also to seize and hold terrain, to engage in street fighting in built-up areas, to sweep woods, to cross water obstacles, to engage hostile armored troops and to perform other combat missions.

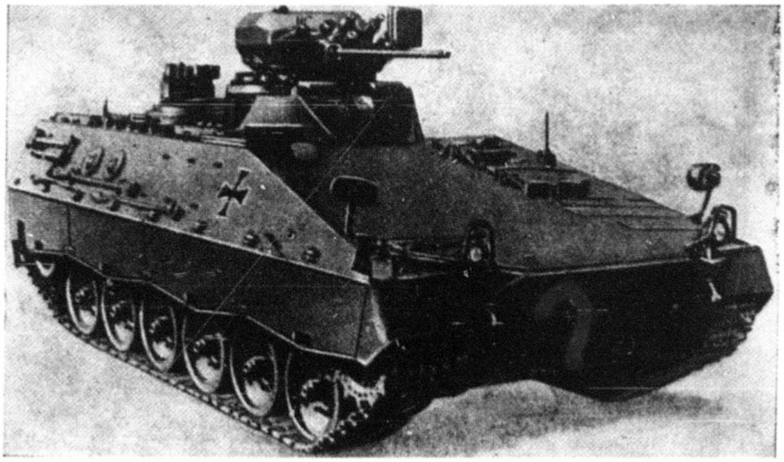


Figure 1.3.3. Marder Infantry Combat Vehicle (FRG)

Only tracked APCs are presently operational in the Bundeswehr. These include the well-known U.S. M113 APC, the HS-30 APC, developed by the Swiss company Hispano-Suiza, as well as the SP1A, developed by the French company Hotchkiss on contract for the Bundeswehr. The HS-30 and SP1A APCs are not amphibious. The HS-30 APC is intended for transporting on the battlefield infantry supporting tank combat actions, while the limited-accommodation SP1A is used in reconnaissance units and for liaison. According to published reports, in the near future the West Germans plan to replace the obsolete, relatively slow SP1A APC (which went into service in 1960) with an 8-wheeled amphibious vehicle of German manufacture, testing of which was completed at the end of 1973.

The obsolete HS-30 tracked armored personnel carrier (in service since 1959) is being replaced as rapidly as possible in motorized infantry brigades with the Marder infantry combat vehicle (Figure 1.3.3). According to published reports, by the beginning of 1976 there were already 2,100 Marder ICVs on the line.

The main armament of the Marder ICV -- a 200 mm automatic gun with coaxially mounted machinegun -- is mounted above the two-man turret and can be used to engage both ground and air targets. A second machinegun is mounted over a small cupola located at the rear of the ICV, where there are also mounted devices for laying smoke screens. The commander, depending on the combat situation, may position himself in the turret together with the gunner, or behind the driver. Six riflemen are carried in the hull aft of the turret. On each side there are two spherical mantlets, through which the riflemen can fire their personal weapon. Another rifleman is positioned under the small cupola, for firing the rear machinegun.

The Marder ICV weighs 28.2 tons (with skirting plates), that is, the vehicle carries fairly thick armor protection. It negotiates water obstacles with the aid of its tracks and special elastic floats, which can be mounted on the sides in 10 minutes.

The French Army operates both tracked and wheeled armored personnel carriers.

The TT6 Hotchkiss (in service since 1952) and AMX VVTM 56 (based on the AMX-13 light tank and adopted in 1955) tracked armored personnel carriers are today considered obsolete and are being replaced by the AMX-10P infantry combat vehicle (Figure 1.3.4), which entered service in 1973.

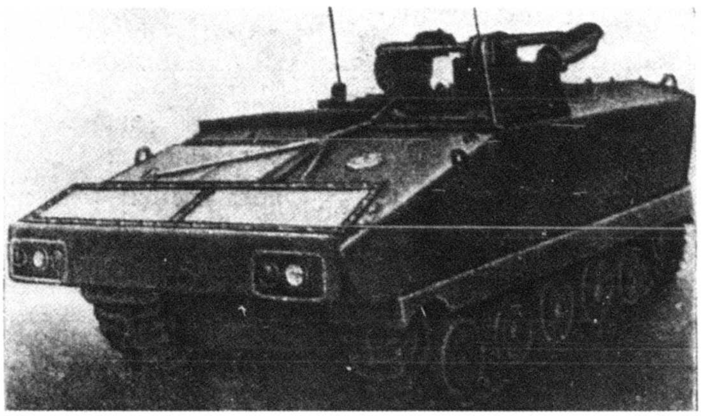


Figure 1.3.4. AMX-10P Infantry Combat Vehicle (France)

The AMX-10P ICV, meeting military requirements adopted by France in 1965, is designed not only to carry motorized infantry but also to be employed by mechanized combined units to operate in coordination with tanks, to provide tanks with cover and to widen penetration.

According to the views of French military leaders, in developing modern combat vehicles the greatest attention should be focused on mobility and firepower. The term "mobility" also includes capability to negotiate water obstacles without special engineer equipment, since the latter cannot always be employed.

The AMX-10P ICV weighs approximately 14 tons. It holds 11 men, as follows: a driver forward on the left side, in the driving compartment, which connects with the trooper compartment; gunner and commander in the turret; eight infantrymen in the trooper compartment.

A large electrically-operated door at the rear of the vehicle swings down and forms a ramp used by the troopers to mount and dismount, as well as for loading and off-loading supplies. Two small exits are built into the rear door for crew egress under combat conditions. In addition, there are two hatches in the roof of the trooper compartment.

With the aid of observation periscopes (three at the driver's position, seven in the turret, seven in the trooper compartment), crew members and troopers can observe in all directions, which improves capability to deliver aimed fire from on-board armament and personal weapons, as well as improving troop dismounting capability. Troopers can deliver fire from their personal weapons through ports in the small rear doors. In addition, troopers can fire through the roof hatches.

AMX-10P ICV armament consists of a 20 mm automatic gun and coaxial 7.62 mm machinegun which, in the opinion of foreign experts, provides capability to engage light combat vehicles at ranges up to 1,000 meters, as well as air targets.

The hull of the AMX-10P ICV is of welded aluminum alloy plates, while the turret is cast. The thickness and slope of the armor plates provide protection against heavy caliber machinegun fire. An air filtering and ventilation system provides protection against nuclear, chemical, and bacteriological weapons.

Maximum speed of the AMX-10P is 65 km/h. It can swim across water obstacles with the aid of water jets and its tracks. Low ground pressure (0.53 kg/cm^2) indicates the vehicle's excellent capability to negotiate poor-traction terrain (swamp, snow, sand).

France has developed a "family" of vehicles based on the AMX-10P. Some of them are tracked, while others are wheeled. All are amphibious and have a single engine-transmission compartment; suspension is hydropneumatic, with variable clearance.

Ground troops in Great Britain, just as in France, are equipped with wheeled and tracked armored personnel carriers.

The FV432 Trojan tracked APC (Figure 1.3.5), in service since 1963, is designed to carry personnel on the battlefield. It has a watertight armor hull which protects personnel against small-arms fire and shell fragments. Eleven troopers are accommodated along the sides of the hull. Armament is a 7.62 mm machinegun mounted in the commander's hatch.

Top speed on land is 52 km/h. For swimming across water obstacles, the armored personnel carrier is equipped with a special screen-type flotation device similar to that of the Centurion tank. The vehicle is powered across water by paddling action with the tracks.

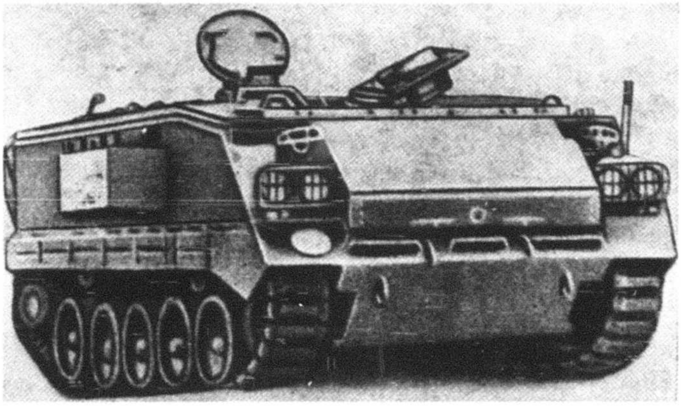


Figure 1.3.5. FV-432 Trojan Armored Personnel Carrier (Great Britain)

According to published information, Switzerland has developed a modernized ICV, which has been given the designation Typhoon, based on the Tornado ICV.

In addition to the above, tracked armored personnel carriers of domestic manufacture are being built in Austria, the Netherlands, Switzerland, Sweden, and Japan.

2. Wheeled Armored Vehicles

In recent years there has been observed the process of intensified development of wheeled armored vehicles which, in the opinion of foreign experts, is due to ever increasing demands pertaining to mobility and general protection of ground troops, development of concepts of combat employment of WAV* of various role, and considerable advances in the area of their design.

The general design features of WAVs are determined by the fact that their manufacture is set up on the foundation of the automotive industry.

The specifications and performance characteristics of WAVs are characterized by the following principal features, as compared with tracked armored vehicles of approximately the same role:

they are better adapted than tracked vehicles to execute long marches at a rapid pace; they are capable of traveling at high speed on hard-surface roads without damaging the road surface; the crew tends to tire less rapidly as a consequence of quieter operations, a smoother ride, and less vibration; fuel consumption

* Wheeled armored vehicles of various role shall henceforth be designated WAV in this text.

per motorized rifleman in a wheeled vehicle averages from 67 to 55 percent that of a tracked vehicle with the same carrying capacity;

WAVs are usually more reliable and economical to operate: engine time between overhaul is three to five times greater, and six-eight times for running gear; a WAV is characterized by less sensitivity to disruptions in the extent and frequency of servicing, while labor required in servicing comparable vehicles ranges from one half to one third as much; relative requirements in repair, servicing and supply facilities are lower for the WAV, which makes it possible substantially to reduce stocks of supplies and maintenance facilities.

At the present time WAVs are extensively employed in the armies of capitalist countries. The majority of these vehicles range from 5 to 20 tons, which is considered by foreign experts to be the most reasonable limit, proceeding from their role, performance characteristics, as well as from considerations of economy;

as regards overall protection capabilities, WAVs are for all practical purposes equivalent to tracked combat vehicles of the same category, but a wheel drive system is significantly inferior to track drive in combat survivability.

The present generation of WAVs is represented by a very broad variety of vehicles. They include combat reconnaissance vehicles (CRV), light and heavy types, wheeled armored personnel carriers (APC), infantry combat vehicles (ICV), combat support and supply vehicles.

In the opinion of foreign experts, the following general directions can be noted in improvement of vehicles of these types:

further strengthening of armament and protection;

efforts to achieve a substantial increase in mobility by increasing vehicle power, speed and cross-country performance, including trench-crossing capability and a requisite level of water obstacle crossing ability;

extensive standardization of component parts and development of extensive "families" of vehicles.

Wheeled combat reconnaissance vehicles carry comparatively powerful armament, strengthened armor protection, and are designed to carry a small crew. Vehicles of this type, in addition to performing reconnaissance missions, engaging enemy personnel and weapons, are employed for unit security, transporting liaison officers, and are also enlisted to engage enemy armored targets in favorable situations.

Light vehicles of this type carry machinegun armament or a small caliber automatic gun. The armored hulls are as a rule of the enclosed type, with a turret. Armor protection is usually adequate against small arms, but in a number of new designs protection is provided against projectiles fired by small caliber guns.

The Fox light combat reconnaissance vehicle (Figure 1.3.6) is a two-axle vehicle with all-wheel drive. It has an aluminum armor hull. The hull front plates provide protection against heavy caliber machinegun fire. A 30 mm automatic gun

is mounted in the turret. It is also armed with a 7.62 mm machinegun and smoke bomb dischargers. The vehicle contains an air filtering and ventilation unit, a radar, navigation instrument, and a nuclear weapon warning system. Night vision devices are provided for the driver.

Figure 1.3.6. Fox Wheeled Combat Reconnaissance Vehicle (Great Britain)

The vehicle weighs 5.8 tons and is powered by a 198 horsepower motor. The vehicle's maximum speed is 90 km/h, and it has a range of 1,000 km.

A flotation screen is provided for crossing water obstacles; when the screen is mounted, sufficient displacement is obtained for buoyancy. When afloat, the vehicle advances and turns propelled only by its drive wheels. Without preparation, the vehicle can wade to a depth of 0.9 m. The vehicle has a three-man crew.

Figure 1.3.7 shows the Luchs heavy wheeled amphibious combat reconnaissance vehicle (FRG). It is a four-axle vehicle with all-wheel drive and all wheels steerable. The vehicle weighs approximately 19.5 tons. Its main armament is a 20 mm automatic gun and a coaxial 7.62 mm machinegun, mounted in a two-man turret. The vehicle carries 500 rounds for the gun and 2,000 machinegun rounds. The hull frontal armor provides protection from 20-30 mm automatic guns fired from a range of 800-1,000 m. The vehicle is equipped with an air filtering and ventilation unit, which maintains an overpressure inside the sealed portion of the hull. The vehicle is operated by a four-man crew, including two drivers.

One feature of this vehicle's general layout is placement of the powerplant in the middle part of the hull, and the fact that there are two driver positions. The engine develops a maximum of 390 horsepower. The hydromechanical transmission contains a reversing gear, and therefore top speed forward and reverse are equal, 96 km/h. The vehicle is provided with excellent cross-country performance by employing 14.00 x 20 tires, a variable pressure system, substantial ground clearance, of 405 mm, and high angles of approach and departure (65-67°). The vehicle is capable of crossing ditches up to 1.9 m wide, climbing a grade up to 35°, and negotiating a vertical obstacle up to 0.9 m. Speed afloat is up to 11 km/h. The vehicle has a range of 800 km.

The French AMX-10RC combat reconnaissance vehicle (Figure 1.3.8), carrying powerful gun armament, can perform missions of engaging enemy tanks. The vehicle has a three-axis chassis with all-wheel drive. Main armament is a 105 mm gun mounted in

a turret. The fire control system includes a laser range finder and automatic correction. The vehicle carries a four-man crew. It has a low silhouette and has high mobility. The vehicle is powered by the powerplant of the "family" of AMX-10 light tracked vehicles, which includes a turbocharged 280 horsepower diesel and a transmission package consisting of a torque converter and a mechanism which combines the functions of gearbox and steering mechanism. The vehicle can turn "like a tank," with the wheels on the right and left sides of the vehicle turning at different rates. Maximum road speed is 85 km/h, average cross-country speed ranges up to 40 km/h, and speed afloat is 8 km/h. The vehicle has a range of 800 km. The suspension system has a variable clearance feature.

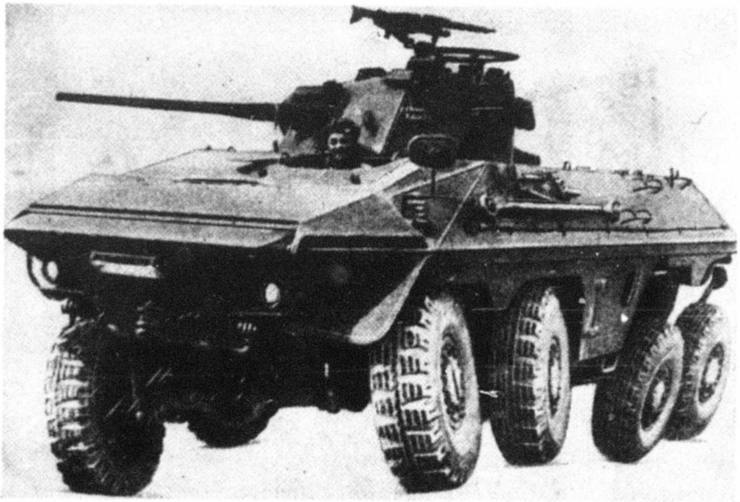


Figure 1.3.7. Luchs Wheeled Combat Reconnaissance Vehicle (FRG)

Figure 1.3.8. AMX-10RC Wheeled Combat Reconnaissance Vehicle (France)

As early as World War II armored personnel carriers became the most numerous type of wheeled armored vehicles; these are intended primarily for transporting motorized rifle units to the battlefield. The motorized riflemen then dismount and fight in dismounted formation with fire support provided by the organic weapons of the armored personnel carriers.

In the opinion of foreign experts, it is expedient to employ wheeled armored personnel carriers to carry infantry on the battlefield and for participation in combat in cooperation with tracked combat vehicles only with a favorable combat situation and terrain.

As a rule wheeled armored personnel carriers are armed with machineguns, while in certain instances they also carry modern weapons for engaging armored targets and low-flying aircraft. The principal design feature of armored personnel carriers is the fact that the armored hull is made large in order to accommodate the troopers being transported, and therefore the armor protection on these vehicle can only defeat small arms fire. As a rule the hull is of the enclosed type.

Figure 1.3.9. M706 Commando Wheeled Armored Personnel Carrier (United States)

Depending on the number of personnel transported, wheeled armored personnel carriers can be small, medium, and large. Small-accommodation armored personnel carriers include vehicles which carry up to a motorized rifle squad; if up to two squads can be accommodated, the APC is assigned to the medium category; an APC which can carry more than two squads is assigned to the large-accommodation category. At the present time medium armored personnel carriers are the most common.

The U.S. M706 armored personnel carrier is an example of a medium capacity two-axle wheeled APC (Figure 1.3.9).

This APC accommodates 12 men. The main armament is mounted in a turret. It consists of a 12.7 mm heavy caliber machinegun and coaxially mounted 7.62 mm machinegun. The APC weighs approximately 7 tons. Hull armor thickness ranges from 6.35 to 9.5 mm. The engine develops a maximum of 185-220 forsepower. The transmission is mechanical. The suspension is rigid axle type. The tires are bulletproof, with variable carcass thickness. Maximum speed is 104 km/h, and vehicle range is 800-900 km. The vehicle's speed afloat is 6.4 km/h. It can climb a grade of up to 35 degrees with a maximum heel of 22 degrees. Turning radius is 6.9 m on land and 7.8 m afloat. On the whole the vehicle boasts excellent cross-country performance.

Figure 1.3.10 shows the Soviet BTR-60PB four-axle medium capacity amphibious armored personnel carrier. This APC carries a heavy caliber machinegun and a coaxially mounted 7.62 mm machinegun. The machineguns are mounted in a rotating turret. APC armament also includes assault rifles carried by the driver and troopers, and a hand-held antitank rocket launcher.

Figure 1.3.10. BTR-60PB Wheeled Armored Personnel Carrier (USSR)

The APC weighs approximately 10 tons and accommodates 10 men seated. The vehicle is powered by two engines with a combined 180 horsepower. The transmission is mechanical, with an all-wheel drive capability under difficult road conditions (8 x 8), while under good road conditions the wheels of the two rear axles are the drive wheels (8 x 4). The right-hand engine powers, through the transmission, the wheels on the first and third axles, while the left-hand engine powers the wheels on the second and fourth axles. Controls are power-assisted. All wheels have independent torsion-bar suspension. The vehicle features a tire pressure adjustment system, which greatly improves the vehicle's mobility on soft ground. The APC is equipped with a water jet for crossing water obstacles. There are two water removal systems to increase safety of operation afloat.

A winch is mounted on the bow for self-recovery and for recovery of vehicles of the same type. Tractive force on the winch cable is 4,500 kg. Maximum vehicle speed is 80 km/h, and maximum swimming speed is 9-10 km/h. The vehicle is capable of climbing a grade up to 30 degree on firm soil. The vehicle can cross a ditch approximately 2 meters wide.

Foreign wheeled infantry combat vehicles are represented by a number of models. France, for example, developed the AMX-10RP wheeled infantry combat vehicle (Figure 1.3.11), which is used in reconnaissance units. This infantry combat vehicle is based on a three-axle chassis (6 x 6). The vehicle is armed with a 20 mm automatic gun, on the turret on an external mount. The general layout provides a low silhouette. The vehicle is characterized by high mobility. Maximum speed is 80-86 km/h. Maximum speed afloat is 8 km/h.

In addition to the wheeled armored vehicles described above, there are vehicles which have been designed, armed and equipped with additional gear for the performance of special combat support missions.

WAVs with antitank weapons are one such special type of vehicle. One of the first vehicles of this type was the British Ferret missile launch vehicle, armed with Vigilant ATGMs. A later modification carries four Swingfire ATGMs. The missiles are carried in pairs along the sides of the turret in armored launching tubes.

A machinegun is mounted in the aluminum armor turret; the missile operator is also stationed there.

Figure 1.3.11. AMX-10RP Wheeled Infantry Combat Vehicle (France)

French light armored vehicles of a similar type include the AML vehicle, which carries four Entac ATGMs.

A light self-propelled antiaircraft weapon, carrying two 20 mm automatic guns, was developed on the chassis of the French AML-245 light reconnaissance vehicle.

In a number of instances the chassis of wheeled armored vehicles are used as a basis for control vehicles for surface-to-air missile systems.

In addition to a transport vehicle and weapon for modern modernized infantry units, wheeled APCs can be employed, in the opinion of foreign experts, for logistical support and for evacuating wounded during combat.

SECTION II. COMBAT PERFORMANCE CHARACTERISTICS OF TANKS

Chapter 1. LAYOUT OF TANKS

Any tracked armored combat vehicles of quite diversified combat role, with a varying level of development of performance characteristics and the most diversified design, weighing from 10 to 60 tons, are frequently called tanks. In our subsequent discussion the term "tank" shall apply only to a main battle tank: a multirole combat vehicle suited for combat under direct hostile artillery fire, combining armament, armor protection, and mobility. Tanks are the most effective and versatile weapons, capable of aggressive actions in various types of combat and of successful accomplishment of a broad range of fire missions. In addition, the sophisticated design of the main battle tank determines in large measure the level of development of the entire aggregate of other combat vehicles which play a particular combat role: infantry combat vehicles, self-propelled artillery, tank destroyers, etc. For this reason all the world's developed countries devote great attention to the development of tank combat performance characteristics: firepower, armor protection, and mobility on the basis of improvement of their layout, design and construction of tank parts, assemblies and mechanisms.

Tank layout is defined as the mutual positioning of the tank compartments and crew stations in the vehicle's armor-enclosed space, positioning of weapons, powerplant, and other tank equipment, mechanisms, and systems. The general layout characterizes the number and mutual positioning of tank compartments, placement of crew, design and construction of tank hull and turret. Particular layouts detail the arrangement of each compartment, tracks and suspension. When designing (synthesizing) a new tank on the basis of preselected, scientifically substantiated specifications and performance requirements, its general layout is the most critical stage, which determines weight, dimensions and, indirectly, cost, within the framework of which the level of individual performance characteristics and the vehicle's combat effectiveness as a whole, as specified by performance requirements, can be engineered. In addition, the overall synthesis of a tank, which includes, in addition to layout, preliminary determination of optimal crew size, selection of armament, powerplant, tank equipment and mechanisms, often opens up the way for improvement of the combat performance characteristics specified in the tactical-technical requirements, without great complication or increased cost of manufacture, and reveals additional reserve potential for improving the military-economic effectiveness of the tank being designed. The layout of existing and future tanks is evaluated from the standpoint of meeting the following principal demands.

1. Demands on Tank General Layout and Ways to Achieve Them

The principal task of layout is to ensure excellent preselected tank performance characteristics with the smallest possible weight G, dimnesions L_0, B_0, H_0 (Figure 2.1.1), and cost. The principal way to achieve this is to reduce the vehicle's armor-protected interior space and, consequently, to reduce the overall area of armor protection. Reduction of tank interior space (without cramping the crew and degrading tank performance characteristics) is fostered by selection of the optimal general layout and compact, small-size armament, engine, equipment and mechanisms; dense vehicle layout, with minimum volume of armor-enclosed air; decreasing tank crew size by mechanization and automation of fire control and tank operation; removal of certain secondary, difficult-to-destroy or easily-replaced tank components to the outside of the armor-enclosed space. The protecting thicknesses of hull nose, side and rear armor on the majority of foreign tanks have approximately the ratio 2.5:1:0.5 (Figure 2.1.2). A decrease in height has the greatest effect on increasing hull armor protection (at a given weight); employment of lightweight metal and polymeric materials in tank construction abroad also opens up extensive possibilities for reducing the weight of a tank with specified performance characteristics or improving its performance characteristics while keeping weight constant.

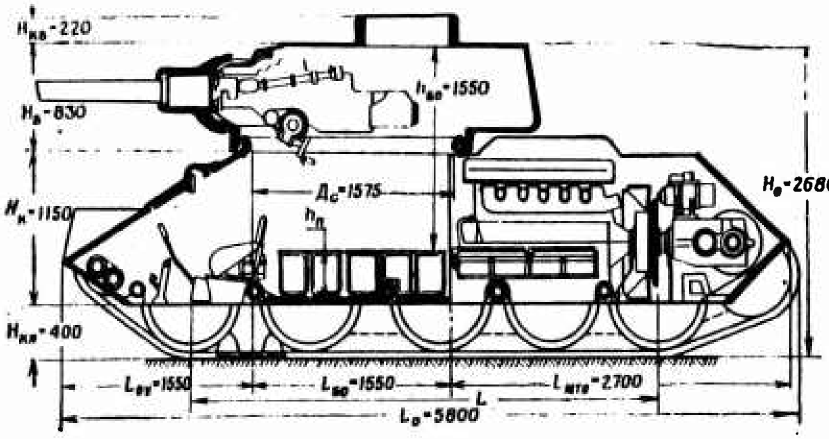


Figure 2.1.1. Diagramatic Layout of T-34 Tank:

L_0, H_0 -- tank dimensions; $Д_c$ -- inside diameter of turret ring; H_k, $H_б$, $H_{кб}$ -- height of hull, turret, commander's cupola; H_k -- road clearance; $h_п$ -- height of interior floor above hull floor; $h_{бо}$ -- height of fighting compartment; L -- length of track bearing surface

---

Another important demand on tank layout is that of installing powerful armament and ensuring its efficient utilization: high maneuverability and accuracy of fire, requisite artillery system rate of fire, and an adequate carried supply of ammunition. This requirement is met chiefly during the particular layout of the tank fighting compartment. Of the general layout measures, we can note only the following: placement of the fighting compartment in the tank midsection, which ensures approximately equal angles of depression when firing forward and rearward, lessens the adverse effect of principal tank pitching movements on the crew, and promotes uniform distribution of ground pressure along the length of the tank track bottom

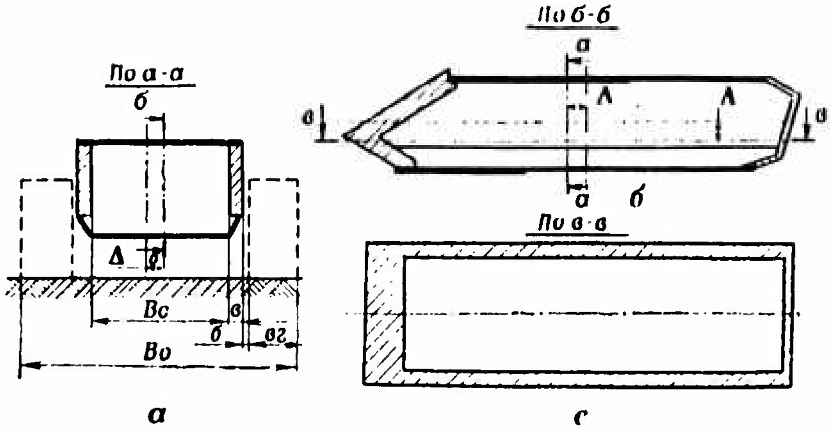


Figure 2.1.2. Schematic Sections of Shellproof Hull:

B_0 -- tank width, including tracks; B_c -- hull interior width; $B_г$ -- track width; σ -- clearance between hull and track

run; large fighting compartment interior volume within the tank hull and turret, running to 6-7 m^3 and comprising 50-60 percent of the vehicle's total armor-enclosed space; large turret ring interior diameter $Д_c$ (see Figure 2.1.1), which limits the size of the artillery system mounted in the turret. This is achieved by maximally increasing interior hull width B_c (see Figure 2.1.2) and additionally widening the upper part of the hull in order to accommodate a large under-turret armor plate.

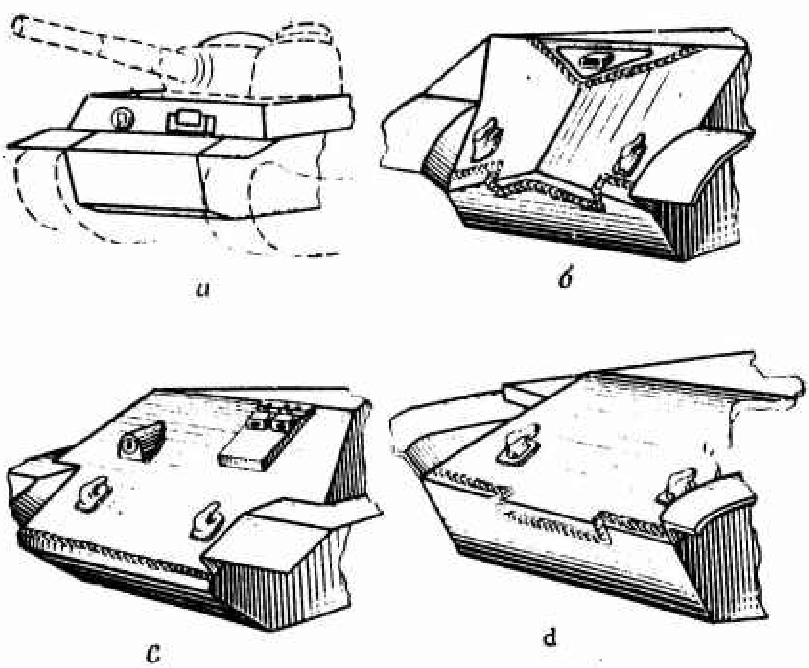


Figure 2.1.3. Tank Hull Nose Shapes: a -- KV; b -- IS; c -- T-34; d -- T-55

Reliable tank protection against the principal weapons of individual and mass destruction is achieved primarily by appropriate design and construction of hull and turret armor components, but also depends to a large degree on the adopted overall layout solutions. A decrease in a tank's size, and especially its height H_0 (see Figure 2.1.1), as well as the frontal projection area (silhouette) makes it more difficult to spot a vehicle on the battlefield, decreases the probability of a direct hit on a tank, and makes it more resistant to being overturned by a nuclear burst shock wave. A projectile-resistant shape of hull (Figure 2.1.3) and turret, varying the protective thicknesses of armor plates in conformity with density of projectile hits, and the absence of armor-weakening apertures, visors and hatches on a tank's nose and side projections reduce the danger of penetration of armor protection when the tank takes a hit. All-round armor protection, sealing of manned compartments, and an aggregate of special means of protection make the tank crew comparatively invulnerable to weapons of mass destruction. Special measures to increase protection against shaped-charge projectiles (Chieftan tank), an aggregate of fire-fighting measures, employment of various means of concealment and camouflage, and use of externally-mounted earth-moving equipment enabling a tank to dig in, also lessen a tank's vulnerability on the battlefield.

A tank's high degree of mobility is determined by its speed, good cross-country performance, ease of handling, and considerable range. High speed is attained by equipping a tank with a powerful engine and economical transmission with control servos, and employment of a powerful suspension with efficient shock absorbers. In order to improve a tank's cross-country performance, designers endeavor to lower the vehicle's center of gravity and to increase the track bearing surface in order to reduce the tank's ground pressure q (see figures 2.1.1 and 2.1.2):

$$q = \frac{G}{2Lb_r} \left[\frac{kg}{cm^2}\right].$$

Satisfactory main battle tank performance on sand, snow and soft ground is achieved only when $q \leqslant 0.83$ kg/cm^2.

Idler wheels are placed higher, $H_z \geqslant 0.8$ m, for negotiating sidehill cuts and hurdles, while vehicle road clearance is increased, $H_{k1} \geqslant 0.4$ m, for negotiating posts and tetrahedrons.

Tank turning is facilitated by reducing turning ratio $\frac{L}{B}$; in modern main battle tanks it ranges from 1.45 to 1.65.

In order to increase tank range, designers prefer the most economical engines with low specific fuel consumption, and carrying on board a large fuel supply in armored tanks, in small external tanks permanently connected into the fuel system, and in strapped-on spare drums.

Providing tank mobility under special conditions, the designer specifies installation of night vision devices, navigation gear, and equipment for underwater driving of tanks. In order to be transported long distances, tanks should be rail-transportable, and therefore width B_0 (see Figure 2.1.2) should not exceed 3,414 mm.

The operational mobility and great depth of tank unit combat operations are ensured by selecting wear-resistant track and suspension assemblies which can travel considerable mileage without replacing tracks, large mileage between overhauls, and

employment of multi-fuel engines, which enable vehicles to operate on various fuels (including captured).

An important demand on the design layout of today's and tomorrow's tanks is provision of good conditions of crew in-vehicle habitability and ergonomics, in order to maintain crew working and fighting efficiency for an extended period of time. The former is achieved by convenient crew entry and exit (including emergency), adequate space and requisite dimensions of work station for each crew member, by comfortable body position during combat and travel, by providing capability for crew members to rest in a lying position, at least taking turns, by lowering the noise and vibration level in the tank, by isolating the crew from heat and gas releasing components of armament powerplant and transmission, by forced ventilation with fume extraction, air conditioning (purifying, heating or cooling), protection against dust, cold, heat, snow and rain, and by carrying adequate supplies of drinking water and food.

Favorable ergonomic conditions for crew functioning are provided by the following: good exterior visibility for all crew members and all-round battlefield observation for the commander both day and night; simplicity and ease of fire control and tank operation; convenient placement of controls (levers, pedals, steering wheel, handles, etc), observation instruments, gunsights, instruments and control panels, and adequate panel lighting; reliable and clear external and internal communications; capability of direct communication, mutual assistance and interchangeability for all crew members. The latter also has a positive effect on the crew's psychological state in combat.

2. Classification and Comparative Evaluation of Tank General Layouts

There are three basic tank layouts, on the basis of crew size and arrangement (Figure 2.1.4): with separated crew, where the driver is positioned in the hull, while the other crew members (two or three) are in the turret; with the crew, usually reduced numbers (to three), entirely positioned in the hull, and with reduced crew (including driver), entirely positioned in the turret.

The first, most common arrangement (Figure 2.1.4a), with which the reader is acquainted from the majority of modern tanks, is characterized by an efficient placement of crew members from the standpoint of combat functions performed. The tank commander, positioned in the upper part of the turret, has all-round battlefield observation capability. The gunner and loader (or a single gunner, in the French AMX-13 tank, for example) are positioned directly by the gun they serve. The driver has a clear view of the road from the forward part of the hull and operates the engine and transmission with the aid of comparatively simple control linkages. A drawback of this arrangement is the large size ($H_{\text{б}}$) and weight of the turret, which contains the unwieldy gun breech ring, three (or two) crew members, and a considerable amount of equipment, as well as the considerable hull height H_k, required to provide the driver a normal sitting position. Tank height H_0 (Figure 2.1.1) is determined with the formula

$$H_0 = H_{\text{кл}} + H_k + H_{\text{б}}.$$

It will not be less than 2.3-2.4 m.

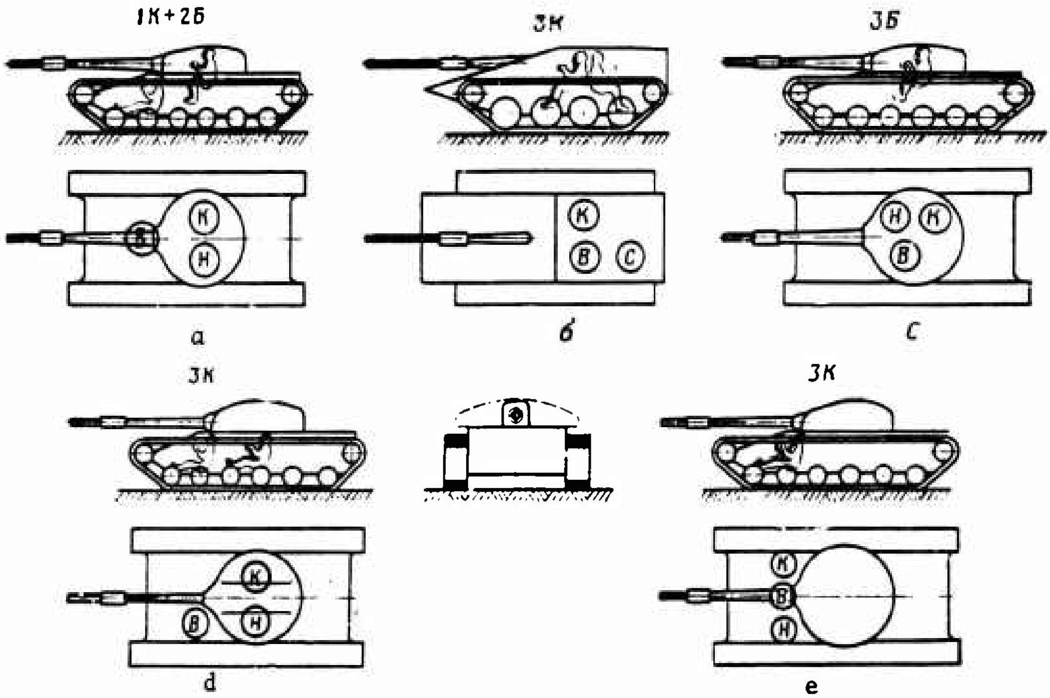


Figure 2.1.4. Layout Diagrams of Foreign Tanks With Varying Crew Size and Placement:

a -- separated placement of reduced crew; b -- crew in hull; c -- crew in turret; d -- semiturret tanks with separated crew; e -- semiturret tank with crew forward in hull

k -- commander; H -- gunner; B -- driver; K -- hull; б -- turret

An arrangement with the crew positioned in the hull is inevitable for turretless tanks (Figure 1.1.5) and for semiturret tanks -- with reduced turrets which contain only the breech end of the gun (Figure 2.1.4d, e).

The most interesting semiturret tank version* (Figure 2.1.4d) has the driver placed in the nose of the hull, with the commander and gunner positioned under the turret but entirely within the hull. Decrease in the frontal silhouette area of such a tank makes it more difficult to spot on the battlefield and decreases probability of a turret hit. Armor savings achieved by sharply reducing turret size creates a reserve for increasing firepower, increasing hull armor protection, or improving mobility. It becomes easier to provide special protection for the crew, which is concentrated in the hull. Placement of each crew member proves efficient, just as in the first layout arrangement.

Foreign experts list the following drawbacks of such a tank: necessity of automatic gun loading, since there is no room for a loader to work in standing position; considerable periscopic requirement for the tank commander's observation instrument,

* The design received an award in competitions held regularly in the United States for suggestions to improve armored equipment.

providing all-round battlefield operation; cramped interior armor enclosed space, which for all practically purposes is limited to the hull interior space.

The third layout arrangement, with the entire crew positioned in the turret, is used in the experimental West German-American MBT-70 tank. The driver's cab is suspended from the turret roof on a miniature ball-bearing support. The cab gear is meshed with the central pinion, fixed to the tank hull floor, in such a manner that when the turret rotates, it causes the cab position to shift without turning relative to the tank hull. Electrohydraulic linkage connects the controls in the cab with the engine and transmission, which are located in the hull. Moving the driver from the hull into the turret eliminates the limitation on hull height and, with a low-silhouette powerplant, makes it possible to shorten the height of the hull and of the entire tank as a whole. Shortening hull height produces the greatest savings in armor plate, making it possible to improve the tank's principal performance characteristics.

Placing the driver in a cab which rotates relative to the turret makes it possible to turn the cab toward the hull rear, providing a good view of the road when backing up the tank. Crew member biological protection, mutual assistance and interchangeability are facilitated, and their psychological state is improved.

Drawbacks of the third layout arrangement include the large, cumbersome turret and complexity of control linkage design. Changing the driver's position relative to the hull makes driving the tank more difficult, and in addition, at certain turret turn angles the commander's observation instrument blocks the driver's instrument, making it impossible for him to observe the road.

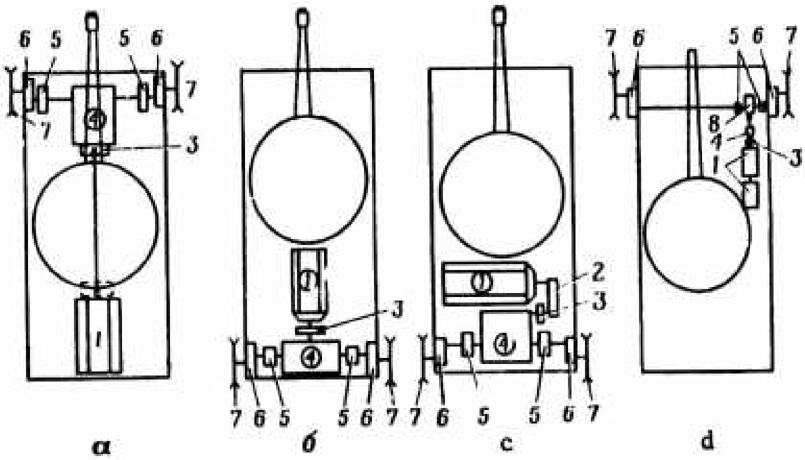


Figure 2.1.5. Diagrams of General Tank Layouts With Differing Transmission Placement

Key:

a.	Transmission forward	2.	Gear train
b.	Transmission at the rear	3.	Engine clutch
c.	Rear placement (with transverse engine)	4.	Gearbox
		5.	Steering mechanism
d.	Forward, to the side	6.	Final drive
1.	Engine	7.	Driving sprocket
		8.	Transfer case

Two basic general layouts are recognized, on the basis of location of transmission compartment (Figure 2.1.5): with rear and forward transmission placement. An arrangement with transmission forward was extensively employed on U.S. and German tanks, because of several advantages. Placing the driving compartment together with the transmission compartment reduced the total number of isolated compartments in the tank hull, helped reduce hull length or, with length unchanged, increased the fighting compartment space. It was easier to place the fighting compartment with the heavy turret at the center of the hull, leaving room on the under-turret hull plate for a driver's hatch. Control linkage design was simple, and transmission servicing was convenient.

The principal drawback was an increase in the overall vehicle height:

$$H_0 = H_{кл} + h_п + h_{бо} + h_{кр},$$

which approached 3 meters. Height $h_п$ =400-500 mm from the hull floor to the floor of the fighting compartment was dictated by the propeller shaft, which ran at the height of the engine crankshaft and the gearbox primary shaft. Fighting compartment height $h_{бо}$ =1600-1700 mm with manual loading, is determined by the height of the loader working in a standing position. Roof thickness h_{kp} with armor components extending above it, varies within a broad range, depending on the presence of a commander's cupola. The considerable height of transmission components made it difficult to obtain a shellproof nose shape with steeply sloping armor plates. There was an increased danger of damage to final drives and driving sprockets placed forward. The considerable length of track loaded by tractive effort reduced the efficiency of the track drive and accelerated track wear.

Transmission cooling was difficult, and crew habitability conditions were worsened. It was extremely difficult to install and remove transmission components due to the welded-on nose and under-turret armor plates. These numerous drawbacks led to a universal rejection of a tank layout with the transmission placed forward.

Rear transmission placement has long been a characteristic feature of the layout of Soviet tanks, and this arrangement has also been preferred in foreign countries since the war. Those features noted as drawbacks of the forward arrangement are advantages for rear transmission placement.

The absence of a propeller shaft makes it possible to decrease fighting compartment floor height $h_п$ to approximately one third, and substantially to reduce overall tank height H_0. The hull nose, which does not contain large transmission components, can be given a suitable shape, with the glacis plate sloping at 60 degrees or more. Final drives and driving sprockets positioned at the rear are less susceptible to combat damage. Only the rear inclined track run is loaded by engine tractive effort, which creates conditions for improving efficiency and reducing wear on the track links. The transmission is cooled by blowing air across the components from the engine cooling system. Tank habitability conditions are considerably improved, since the crew is isolated from transmission and engine components by a sealed engine bulkhead. Installation and removal are considerably facilitated by placing removable armor plates on the roof of the engine-transmission compartment.

One drawback of an arrangement with rear transmission placement is that tank length increases due to placement in the hull of four compartments which are not length-integrated, or else a decrease in fighting compartment space with vehicle length

constant. Due to the considerable length of the engine and transmission compartments, the fighting compartment (with heavy turret) is displaced forward, excessively loading the forward road wheels, while no room remains on the under-turret armor plate for central or even lateral placement of a driver's hatch.

On the T-34 tank, the world's best medium tank in World War II, it was necessary to place the driver's hatch on the sloped glacis plate, in spite of the fact that this weakened the resistance of this most critical component of the armored hull to a shell hit.

In order to correct the first two deficiencies, Soviet tanks, beginning with the T-44, employed an improved arrangement with transverse placement of a long, 12-cylinder diesel and a unified engine-transmission compartment which was considerably shorter (by 650 mm) than that of the T-34 tank. This made it possible, without lengthening the hull, to increase the length of the fighting compartment of the T-54 tank to 35 percent of the hull length, to increase turret ring diameter by almost 250 mm, and to mount a powerful 100 mm tank gun for the first time on a medium tank in place of the 85 mm gun of the T-34-85 tank.

At the same time it was possible to shift the turret rearward, freeing room on the under-turret plate for the driver's hatch. Elimination of a fifth crew member, removal of ammunition stowage from the floor of the fighting compartment, transfer of the fan from the engine crankshaft to a bracket on the tank rear, and reducing engine height resulted in shortening the hull height of the T-54 tank by 150 mm in comparison with the T-34, reduced armor-protected space by approximately 2 cubic meters, and permitted armor protection to more than double, which increased weight by only 12 percent.

One design innovation incorporated by the T-55 tank was the employment of tank-racks, providing fullest utilization of armor-protected space for gun ammunition and diesel fuel stowage. As a result of this measure, and by eliminating the antiaircraft machinegun and weakening certain secondary armor components, it was possible to increase quantity of ammunition carried by nine rounds (from 34 to 43), and to increase armor-protected fuel supply by approximately 150 liters (from 532 to 680 liters).

Chapter 2. TANK FIREPOWER

1. Armament of Modern Tanks

The mass-scale employment of tanks and other armored vehicles in modern combat dictates heavily arming troops with close and long-range antitank weapons. Therefore tank weapons should be capable of quickly destroying and neutralizing the most diversified targets on the battlefield -- from an individual rocket launcher-firing trooper in a foxhole to a tank and missile weapon launch positions. This also predetermines tank armament.

Tank armament includes weapons, ammunition supply, gunsights, laying mechanisms, weapon stabilizers, and other devices.

Today tanks are armed with a number of weapons, for performing various fire missions. They include, according to a foreign classification, main and auxiliary armament, while some tanks also carry additional weapons. Figure 2.2.1 contains a classification of tank weapons.

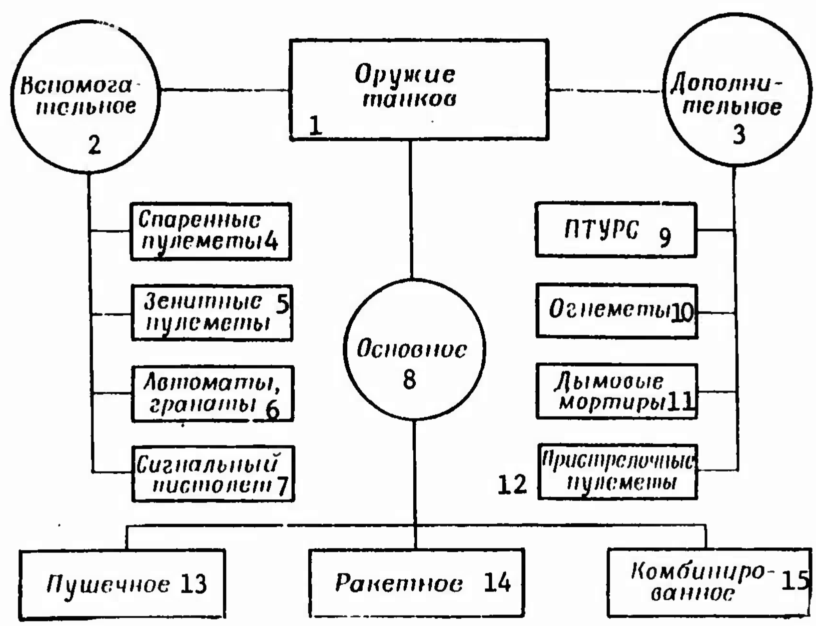


Figure 2.2.1. Classification of Foreign Tank Weapons

Key to Figure 2.2.1 on preceding page:

1. Tank weapons
2. Auxiliary
3. Additional
4. Coaxially mounted machineguns
5. Antiaircraft machineguns
6. Assault rifles, grenades
7. Signal pistol
8. Main
9. ATGM
10. Flamethrowers
11. Smoke dischargers
12. Ranging machineguns
13. Gun
14. Missile
15. Combined

Main weapons are for the purpose of destroying and neutralizing targets possessing considerable firepower and strong protection. These include armored targets (tanks and self-propelled artillery), various field fortifications, enemy artillery and missile launch positions, as well as infantry and infantry weapons. The tank gun is the principal tank main weapon.

The principal type of tank fire is direct fire at all ranges at targets as soon as they are detected. As a rule tank crews independently search for and fire at targets. Tank units deliver concentrated fire at a single target to destroy the most important and largest targets, as well as to accelerate killing of targets at a range of more than 2.5 km.

Auxiliary weapons are used to destroy and neutralize close-range antitank weapons (rocket launchers, recoilless guns, etc), to destroy lightly-armored and slow-flying air targets as well as enemy infantry.

Auxiliary weapons include tank machineguns -- coaxial-mounted, hull-mounted, and antiaircraft. Some foreign tanks carry ranging machineguns.

Additional weapons are employed to perform those fire missions which cannot be successfully accomplished by the principal weapons when delivering fire at long range. This category of weapon includes antitank guided missiles (ATGM), which are carried by some foreign tanks.

The tank gun is mounted as a rule in a rotating turret. The machinegun is mounted on the gun cradle. This combination of gun and machinegun is called a coaxial mounting. The turret is rotated with the aid of electric or electrohydraulic drives operated from a control panel, as well as manually.

The gun (machinegun) is aimed at the target with the aid of a gunsight or rangefinder-gunsight. Night vision sights are provided for firing at night. In addition there are devices for firing under conditions of restricted visibility or when the target cannot be seen.

In order to increase target hit probability when firing while the tank is moving, coaxial mounts are equipped with weapon stabilizers. In order to increase tank gun rate of fire, some tanks (the XM1, for example) feature automatic loading and mechanisms which eject spent cases from the tank.

Thus the armament of a modern tank is a complex system. The firepower of tanks and self-propelled guns is determined by the sophistication of this system and the proficiency of crews.

2. Principal Factors Determining Tank Firepower

A tank's firepower is determined by its capability to destroy or neutralize various targets in the shortest period of time with the least expenditure of ammunition.

Let us examine what principal factors determine a tank's firepower during delivery of fire while moving, when its combat performance characteristics are most fully utilized.

A tank's firepower is determined by the following principal factors: force of effect of a projectile on a target, target hit probability, maneuverability of fire, time of initiation of fire and practical (combat) rate of fire, as well as degree of weapon vulnerability and tank crew habitability.

The interrelationship among the principal factors which determine a tank's firepower when delivering fire while moving can be seen from the diagram in Figure 2.2.2.

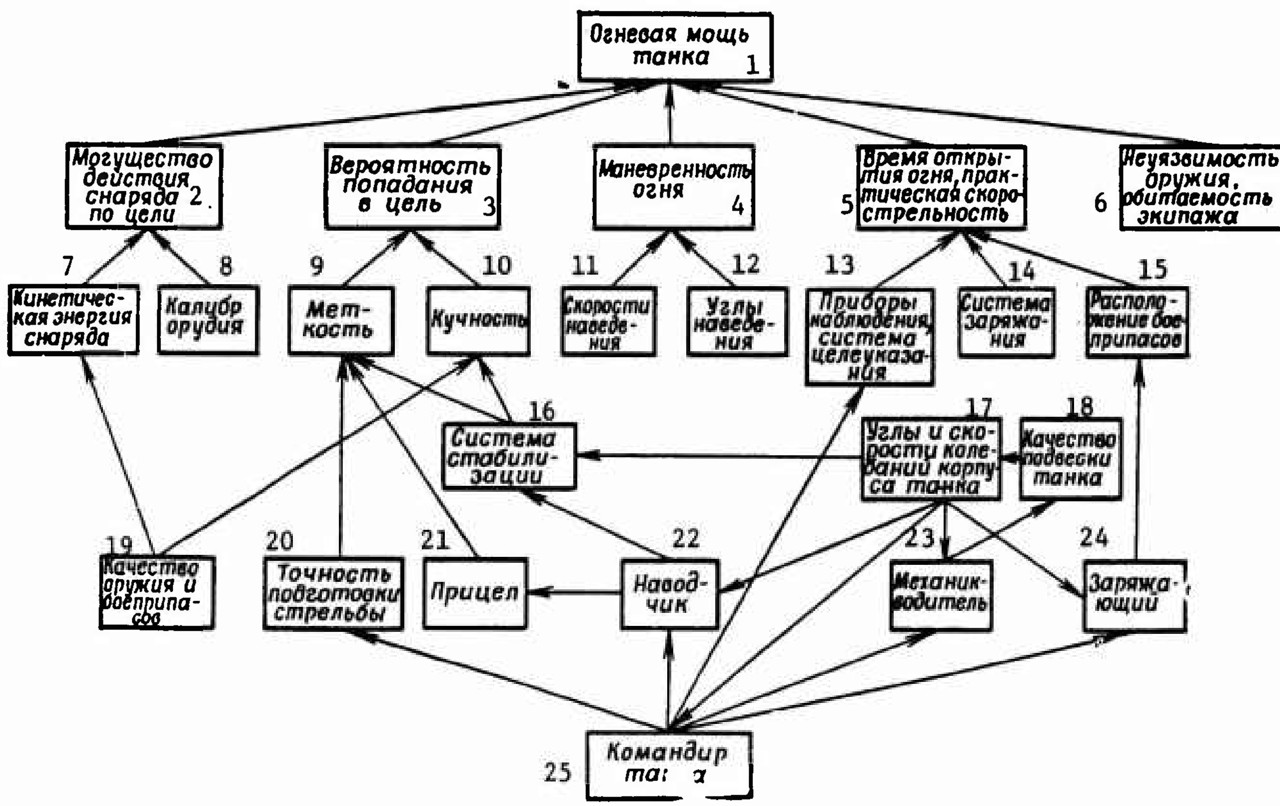


Figure 2.2.2. Diagram of Interrelationship of Principal Factors Which Determine a Tank's Firepower When Delivering Fire While Moving

Key:

1. Tank firepower
2. Force of effect of projectile on target
3. Target hit probability
4. Maneuverability of fire
5. Time of commencement of fire, practical rate of fire
6. Weapon vulnerability, crew habitability

(Key to Figure 2.2.2 on preceding page, cont'd)

7. Kinetic energy of projectile
8. Gun caliber
9. Accuracy
10. Grouping
11. Rates of laying
12. Laying angles
13. Vision devices, target designation system
14. Loading system
15. Location of ammunition
16. Stabilization system
17. Angles and rates of tank hull oscillations
18. Quality of tank suspension
19. Quality of weapons and ammunition
20. Accuracy of fire preparaion
21. Gunsight
22. Gunner
23. Driver
24. Loader
25. Tank commander

A continuous increase in tank firepower has been particularly characteristic of the postwar years. This is due to the fact that tank armament is intended to destroy the most diversified targets on the battlefield, and in particular tanks and antitank weapons. Since the protection of tanks and antitank weapons and their combat capabilities are continuously improving, tank firepower should also increase.

In order to determine the possible paths of future increase in tank firepower, one must analyze the components of each of the principal factors (applicable to the main armament).

3. Increasing the Force of Projectile Effect on the Target

The force of effect by a projectile on a target is determined by the character of the effect it produces upon encountering an obstacle. In order to destroy armored and concrete-protected targets, a projectile should possess considerable impact effect. Projectiles require high explosive or fragmentation effect to destroy various field fortifications and to kill personnel.

At the present time some foreign tanks are employing subcaliber projectiles, shaped-charge shells and shells with plastic explosives against armored targets.

Subcaliber projectiles. Subcaliber is a term applied to projectiles in which the diameter of the armor-piercing portion is less than the caliber of the weapon from which it is fired. The force of effect of a subcaliber projectile is determined by the thickness of the penetrated armor and the effectiveness of the damage done beyond the armor. For a given projectile weight and caliber, armor defeating performance depends on the velocity of the projectile, its angle of impact with the armor, and the quality of the armor. At high angles of impact armor penetration capability is substantially reduced as a consequence of projectile ricochet.

The force of effect of subcaliber projectiles can be increased by increasing their muzzle velocity. This flattens the trajectory, which increases range of direct fire. The greater a projectile's muzzle velocity, the greater its armor-piercing effect, all other conditions being equal. A projectile's muzzle velocity can be increased by increasing propellant gas pressure in the bore and by lengthening the barrel. The latter, however, leads to an increase in barrel size and weight, which creates difficulties in matching it to the tank, and requires an increase in power of gun laying drives.

Long-barreled guns extend considerably beyond the tank hull, which presents a possibility that the barrel will strike the ground when the tank is negotiating obstacles, and it restricts tank maneuver in forest and built-up areas. When projectile muzzle velocity is increased, gun barrel life is sharply reduced, to several hundred rounds.

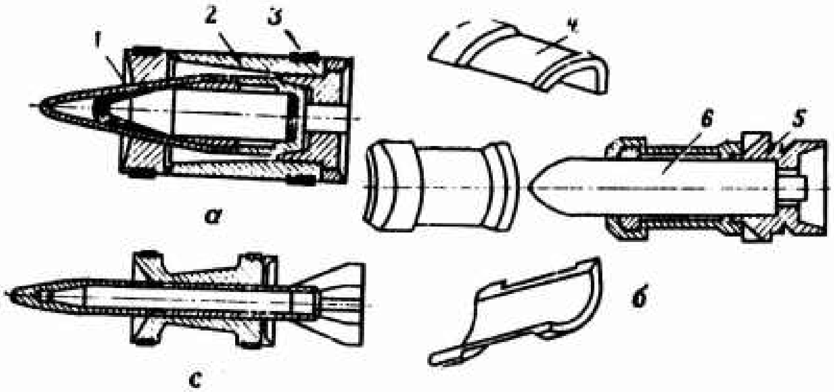


Figure 2.2.3. Projectiles Employed for Tank Guns

a -- subcaliber projectile with discarding sabot; b -- subcaliber projectile with jacket; c -- fin-stabilized subcaliber projectile; 1 -- jacket; 2 -- sabot; 3 -- driving band; 4 -- jacket segment; 5 -- base; 6 -- core

---

The core of a modern subcaliber projectile is carried in a sabot (Figure 2.2.3). After the projectile leaves the bore, the sabot separates from it, under the effect of air resistance. Possessing a good weight to caliber ratio, the projectile retains its velocity well in flight. A different version of such a projectile is the jacketed projectile (Figure 2.2.3b), which consists of three parts, which separate from the core after leaving the bore. The muzzle velocity of the discarding sabot projectile fired by the British 105 mm tank gun is 1,475 mps.

These subcaliber projectiles, however, ricochet at angles of impact with armor less than 35°, while the discarding sabot can do harm to friendly troops situated ahead of the tank.

It is believed that the kinetic energy of subcaliber projectiles and effective range of fire can also be increased by increasing gun caliber. The British Chieftain tank, for example, carries a 120 mm tank gun, which fires primarily subcaliber projectiles.

Foreign countries are devoting greater attention to smoothbore tank guns firing fin-stabilized subcaliber projectiles (Figure 2.2.3c). 105 mm and 120 mm smoothbore guns, for example, are being tested on the Leopard 2K tank. Similar guns are being developed in Great Britain (110 mm) and France (120 mm). In the opinion of foreign experts, such guns impart greater muzzle velocity to projectiles than rifled guns of the same caliber, boast greater armor piercing capability, range of direct fire, and effectiveness in firing at long ranges. This is due to the fact that the muzzle velocity of a subcaliber fin stabilized projectile can reach 1600 mps and more.

Shaped-charge shells. The principal advantage of shaped-charge shells (Figure 2.2.4a) over conventional armor piercing and subcaliber projectiles is their excellent armor

penetration with the same caliber, which is independent of range of fire. A nose fuze actuates upon impact with armor. Its action is transferred to an igniter, which detonates the bursting charge through a detonator. The metal liner is squeezed under a pressure of several hundred thousand atmospheres. A jet of molten metal is ejected from the cone (Figure 2.2.4b) at a velocity of approximately 10,000 mps. The diameter of the jet in medium caliber shells is 3-4 mm. The jet is capable of penetrating armor of a thickness in excess of three times the caliber of the projectile.

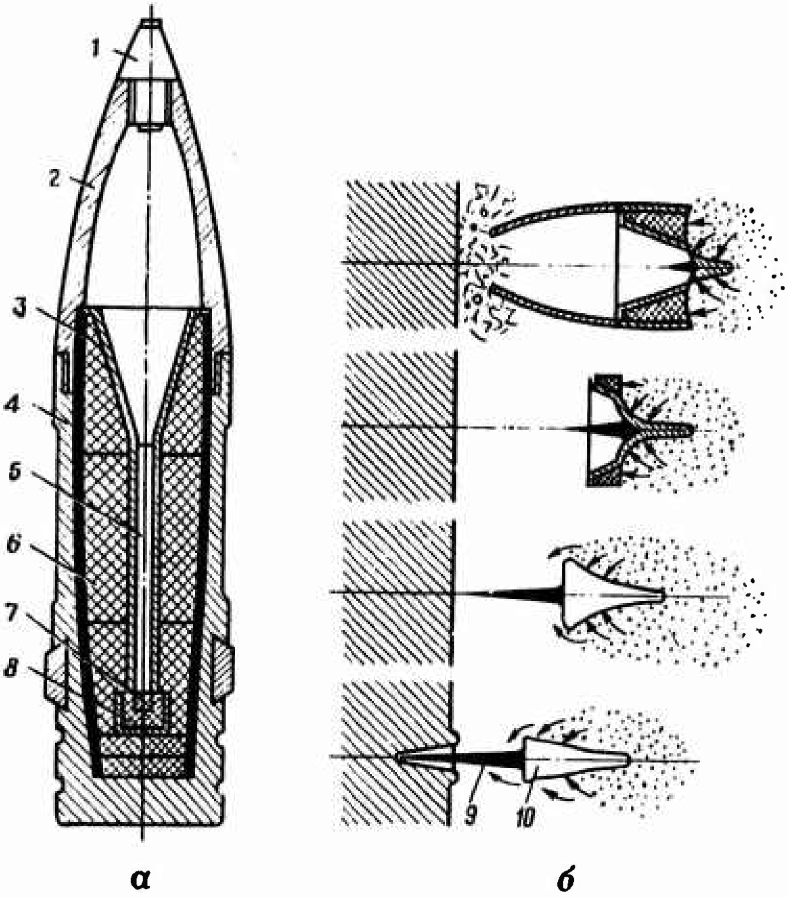


Figure 2.2.4. Shaped-Charge Shell and Diagram of Formation of Jet

Key:
- a. Shaped-charge shell
- b. Diagram of formation of jet
- 1. Direct action fuze
- 2. Screw-on nose cap
- 3. Metal liner (cone)
- 4. Shell body
- 5. Central channel
- 6. Bursting charge
- 7. Igniter
- 8. Detonator
- 9. Jet of molten metal and gas
- 10. Slug

Foreign experts are of the opinion that the armor piercing capability of shaped-charge projectiles is reduced severalfold if the projectiles are rotating at the

moment the bursting charge explodes. This is due to the fact that projectile rotation worsens the conditions of forming of the jet.

They believe that the force of shaped-charge projectiles can be increased by slowing their rate of rotation. Projectiles fired from rifled tank guns spin in flight at approximately 17,000-18,000 rpm, which greatly exceeds the maximum allowable spin rate for shaped-charge projectiles. In order to reduce the spin rate, one can employ a shaped-charge projectile the steel body of which is imparted spin when fired, while the shaped charge, on ball bearings inside the projectile body, remains motionless by inertia. Such a projectile is employed for the 105 mm tank gun of the French AMX-30 medium tank. The manufacture of such a shell requires a high degree of machining precision, which greatly increases its cost.

Projectiles with plastic explosives. Some foreign tanks employ projectiles with plastic explosives against armored and other targets. The mild-steel projectile body is filled with a plastic explosive (a mixture of hexogen and mineral oil). The projectile body readily deforms upon impact with armor. A base fuze detonates the explosive, a compression wave followed by a tension wave passes through the armor, and armor layers on the rear of the plate are imparted enormous accelerations in opposite directions. As a result of this, pieces of armor split off the interior of the plate at high velocity, doing damage to the tank interior.

These projectiles can also be employed against field fortications and unarmored targets.

In the opinion of foreign experts, projectiles with a plastic explosive also have an important drawback: they must be detonated at a precisely established time. Bursting charge detonation time depends on the projectile's terminal velocity and angle of impact with armor, values which vary in relation to range. Therefore the velocity of such projectiles is comparatively low. In addition, skirting plates and other devices can be employed against plastic-explosive projectiles, sharply reducing their casualty effect.

At the present time plastic-explosive projectiles have been adopted for the guns of the U.S. M60 tank, the British Chieftain tank, and the Swedish STRV103B tank.

High-explosive fragmentation shells. High explosive fragmentation shells are used to engage antitank weapons, to kill enemy personnel in an exposed position, to demolish defensive installations, etc.

When an instantaneous fuze is employed, high-explosive fragmentation shells perform as fragmentation shells, and as high explosive shells when employing a graze or delayed action fuze.

Fragmentation effect depends on the quantity of lethal fragments, their pattern of spread, the projectile's angle of descent, depth of crater, character of the soil, and other conditions. Only those fragments the kinetic energy of which is not less than 10 kg/m are lethal. The most efficient fragment weight is q_0=5 grams; lighter fragments rapidly lose velocity, while with greater weight the number of fragments is reduced.

The velocity and number of fragments depend on the caliber of the shell. Approximately 500 fragments are formed by the bursting of a 100 mm shell, with an average fragment velocity of 600 mps.

A zone reduced to a rectangle, within which the probability of target kill is assumed to be 1, is adopted as measure of fragmentation effect. For example, the fragmentation effect zone of a 100 mm shell against standing infantry is 31 m in frontage and 13 m in depth, while against prone infantry it is 22 and 9 m respectively.

The dimensions of the crater which forms when a shell bursts in soil of medium density is adopted as the measure of high explosive effect. For example, the dimensions of a crater produced by the burst of a 100 mm shell are the following: depth -- 0.5 m, and diameter -- 2.4 m.

A further increase in the fragmentation and high explosive effect of shells can basically be obtained by increasing gun caliber.

In recent years the attention of foreign experts has been drawn by projectiles with liquid explosive mixtures. When such a projectile strikes an obstacle, an aerosol cloud of explosive mixture is formed, which can be detonated by various methods. In contrast to conventional shells, the charge distributes over a substantial area, which greatly increases the casualty effect radius.

4. Increasing Target Hit Probability

To destroy a target, it must first be detected. This requires effective observation and aiming devices (sights). Large angular fields of view from a tank are ensured by mounting at crew stations prismatic viewing devices. The number of such devices ranges from 12 to 18 on foreign tanks.

Demands on tank gunsights are difficult to meet. Requirements include high magnification for target detection and identification, and at the same time a large field of view in order to have good observation of the battlefield on a wide frontage. Degree of magnification and size of field of view in a gunsight, however, are linked by inversely proportional relations.

The best combination of requirements in degree of magnification and size of field of view is obtained in so-called pancratic devices, which provide smooth change in magnification and field. This makes it possible rapidly to shift from wide observation along the front to detailed observation of a target. The West German Leopard tank carries a pancratic instrument with variable magnification from 6 to 20 power.

No matter how much the force of projectile effect on a target is increased, a tank's firepower will be poor if a high hit probability is not achieved. The greater the hit probability, the greater is a tank's firepower. Hit probability depends on accuracy and grouping. Accuracy is evaluated by deviations of trajectory to mean point of impact from the center of the target, while grouping is determined by deviations of individual projectiles from the trajectory to mean point of impact.

Increasing accuracy of fire. Accuracy of fire depends on the magnitude of errors in determining and specifying initial weapon settings for fire. These errors depend

for the most part on accuracy of determining range to target, taking into account deviations in fire conditions from standard, as well as the rate of mutual travel of tank and target. In addition, they depend on crew proficiency and firing conditions (day or night, weather, terrain).

Range to target can be determined by eye, by sight or vision device scale, by sight range scale, and with the aid of a rangefinder.

Mean error of determining range by eye is equal to 15 percent of the determined range under good conditions of observation. Determination of range by sight scale is possible only if the dimensions of the target are known in advance. Range is figured with the thousandths formula; mean error in determining range does not exceed 8-10 percent of the determined range.

It is comparatively simple to determine range with the special sight range scale. The range scale is figured, however, only for one specific target height (usually the height of a tank).

At the present time some foreign tanks employ optical rangefinders, combined rangefinders and sights, and laser rangefinders. Figure 2.2.5 contains a schematic diagram of a monocular rangefinder.

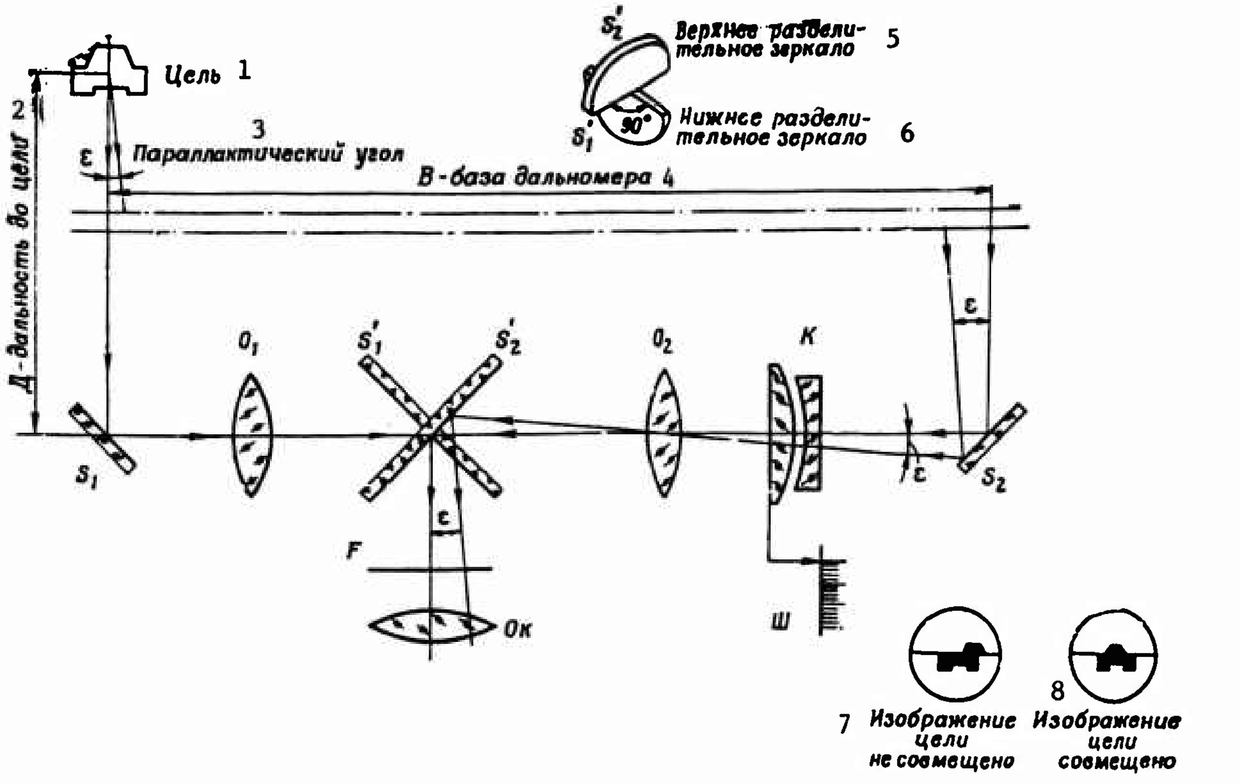


Figure 2.2.5. Schematic Diagram of a Monocular Rangefinder

Key:

1. Target
2. Range to target
3. Parallax angle
4. Rangefinder base
5. Upper split-image mirror
6. Lower split-image mirror
7. Target image split
8. Target image coincides

In monocular rangefinders an optical compensator, consisting of two lenses -- a positive and negative, with identical radius of curvature -- is employed as a measuring device. If the optical axes of both lenses coincide, beams passing through them do not change direction. When one of the lenses displaces relative to the other, beams deflect in the direction of lens movement. The optical compensator, placed in front of the objective lens, makes it possible to superimpose the two image halves.

Thus ranging with a monocular rangefinder breaks down virtually to coinciding the upper and lower parts of the target image by displacing the compensator lens, and reading range off the scale.

Simplicity of measuring range is an advantage of monocular rangefinders. To use them, however, it is essential that the observed objects have contrast outlines, while it is very difficult to measure range to target when tanks are moving.

When a tank contains a separate rangefinder and sight, considerable time is expended on determining range to target and then on setting the sight. Therefore some foreign tanks have a combined rangefinder and sight, in which the sight is automatically set to the measured range.

In the U.S. M-12 combined rangefinder and sight, for example, the range and elevation angle measuring mechanisms automatically set the sight at the measured range, while special cam mechanisms set the sight in conformity with the round selected for firing.

Optical rangefinder range measurement error is directly proportional to the square of the distance, and therefore foreign experts are of the opinion that laser rangefinders make it possible sharply to reduce the time to determine range to target with a high degree of accuracy.

Reducing errors in determining and taking into account deviations in actual from standard firing conditions. Standard firing conditions are conditions which correspond to specific topographic, ballistic, and meteorological characteristics.

As a rule, however, the tank delivers fire under conditions differing from standard. Therefore it is necessary to determine and introduce into the sight corrections which take account of the conditions in which firing is being conducted, namely:

ballistic firing conditions (temperature of the charge, bore wear, tank heel at the moment of firing, angle of sight, etc);

meteorological firing conditions (wind direction and velocity, air temperature, atmospheric pressure);

change in distance between target and tank from the moment range is measured to the moment the projectile impacts the target;

change in direction to target during projectile flight time.

These corrections are selected by the gunner (tank commander) in conformity with general tank gunnery procedures. Some tanks carry ballistic computers, which make

these corrections automatically. The U.S. M60 tank and its modifications, for example, carry an electromechanical ballistic computer which figures in angular displacement of target and several meteorological factors.

We should note that the first ballistic computers were mechanical devices into which the gunner fed, as into an adding machine, corrections for temperature, drop in projectile muzzle velocity, crosswind velocity, speed of target movement, etc, all of which were estimated by the gunner. The the gunner, rotating the handle of this machine, would obtain lead values. Combat operations with employment of U.S. tanks carrying such ballistic computers during the first India-Pakistan conflict showed that in many instances accuracy of fire became worse rather than better. This was due to the fact that in a tense combat situation a tank crew had no time to determine and feed data into the computer, and sometimes incorrect data would be entered.

Therefore at the beginning of the 1970's automated electromechanical or electronic ballistic computers began to be carried by modernized foreign tanks. Data from appropriate sensors indicating charge temperature, crosswind velocity, drop in projectile muzzle velocity, cant of trunnions, and angular velocity of target movement would be fed automatically into these computers. Special gun drives would automatically adjust the gun to the computed lead. During the operation of ballistic computers, some sensors mounted on the tank do not always give acceptable-accuracy data on various firing conditions:

the crosswind velocity sensor, mounted on the tank's turret, records wind direction and velocity approximately at the point of projectile emergence, while it is affected along its entire trajectory by wind which does not always correspond in direction and velocity to that at the projectile's point of origin;

the air temperature sensor is subjected to thermal radiation from a tank's engine, and therefore it does not always provide objective data;

the charge temperature sensor fails to take account of differences in ammunition rack temperature conditions during the time which has passed since the ammunition was loaded.

All this can lead to a situation where ballistic computers themselves can be a source of errors in setting initial firing data. Therefore development of acceptable ballistic computers is a serious problems at the present time.

Improving grouping. Close grouping is obtained by high quality and uniformity of manufacture of guns and ammunition, as well as their careful preparation for firing.

Grouping is affected by deviations in projectile weight, dimensions, shape and position of center of mass. The shape of projectiles determines in large measure the magnitude of air resistance. It is obvious that the larger the manufacturing tolerances, the poorer grouping will be.

Grouping is significantly affected by uniformity of charge temperature, accuracy of weight and uniformity of quality of the propellant charge, as well as barrel rigidity and precision of manufacture.

We should note that improvement of ballistic characteristics of foreign tank guns was achieved primarily by increasing propellant gas pressure and lengthening the barrel. Thermal protection jackets which encase the barrel are employed to improve stability of gun performance. One example is the jacket on the 120 mm gun on the Chieftain tank. Grouping and accuracy of fire during movement are significantly improved when tanks are equipped with gun stabilizers. The greatest effect is achieved by stabilizing a gun in two planes: the gun's tipping parts in the vertical plane, and the turret with gun in the horizontal plane.

We should note that in order to increase accuracy and grouping when firing in movement, alongside efforts to improve the quality of the stabilizer, serious attention is being focused on further improvement of tank suspension. One should bear in mind thereby that equipping tanks with stabilizers does not reduce demands on driver proficiency. Therefore during tank gunnery training it is essential to devote considerable attention to training not only of the gunner but the driver as well.

5. Increasing Maneuverability of Fire

The swift pace of combat operations, the element of surprise and brevity of exposure of targets demand of tank armament a high fire maneuverability.

In order to increase fire maneuverability, tanks carry mechanical drives to ensure maximum speed of laying and rapid switching of fire from one target to another. Of great importance for ensuring accurate gun laying on the target is achievement of minimum stable laying speed. Usually the minimum laying speed ranges from 0.05 to 0.1 degree per second.

Maximum rate of laying for elevation is selected in relation to the system of laying the gun when the tank is in movement. It should not be less than the average value of rates of tank hull pitching. Consequently this rate depends primarily on the quality of a tank's suspension. The required maximum rate of laying for deflection can be determined from the conditions of firing while in movement at a moving hostile tank situated at a range of 100 meters if firing is being conducted at head-on parallel courses and relative speed of target movement, equal to the sum of the speeds of tank and target, is 50 km/h. Under these conditions maximum rate of laying for deflection is equal to 8 degrees per second.

It is essential that rate of laying change smoothly from minimum to maximum. In order to reduce time required to switch fire from one target to another while the turret is rotating to large angles it is essential that the rate of this switch be considerably greater than the maximum rate of laying for deflection. On modern foreign tanks the fire-switching rate of turret rotation shows an increasing trend to 30 degrees per second and more.

Fire maneuverability depends on laying angles. Mounting the gun in a turret provides all-round traverse.

In the vertical plane a high angle of fire enables the tank effectively to utilize its gun for combat in mountain terrain and in large built-up areas. Maximum elevation for a tank gun is 18-20 degrees, and up to 30 degrees for amphibious tanks. A gun's angle of depression determines the size of the dead zone around a tank. Stabilizer effectiveness depends to a considerable degree on the angle of

depression. A small angle of depression does not permit the stabilizer to stabilize the gun with large tank hull pitching angles, since the gun comparatively frequently advances to the lower stop. Therefore efforts are made to increase the angle of depression on modern tanks to 8-10 degrees.

In order to beat the adversary in opening fire, it is necessary first of all to detect him first. Time required to detect a target depends on the quality of the observation devices, number of observers, tank's status during observation (moving or standing), existence of stabilizing devices, and nature of target activity (moving, firing, etc). Stabilized observation devices, for example, are carried on the STRV103B.

Time to open fire, that is, time from the moment a target is detected until the first round is fired, depends to a substantial degree on the commander's target designation system. With the aid of this system, the tank commander should be able from his position to lay the gun approximately on the target. It is more expedient to have a system whereby the range of variation of rates of laying by the tank commander and laying accuracy are the same as when performed by the gunner.

The principal foreign tanks, the M60A2 and the Leopard 1, have commander redundant fire control systems. Such a system, in addition to shortening time for target designation of the tank commander to the gunner, increases tank reliability and combat survivability, since if the gunner or his sight is disabled, the commander can take over for the gunner.

6. Increasing Normal Rate of Applied Fire

Normal rate of applied fire is defined as the greatest number of rounds which can be fired from a gun taking account of aim correction time after each round is fired and change in sight settings. The greater the actual rate of fire, the greater the number of targets which can be killed in a given period of time. Increasing actual rate of fire and fire maneuverability provides the capability to beat the adversary in opening fire and inflicting damage. With manual gun loading, 70 to 75 percent of the time expended on firing a round is spent on loading. Loading time particularly increases when firing while the tank is moving. Consequently, in order to increase actual rate of fire, it is necessary to shorten loading time. Foreign military experts believe that this problem can be radically resolved only by automating the loading process. The aggregate of mechanisms which provide capability to load a gun without the participation of a crew member is called an automatic loader. Automatic loaders are quite diversified in design, depending on the weight and size of the artillery round as well as the size of the tank fighting compartment. Foreign experts believe, however, that an automatic loader should provide the following, regardless of design:

round selectivity;

sufficiently large automated ammunition stowage capacity;

good automatic mechanism operating reliability at all gun and tank attitudes;

complete crew safety during automatic loader operation, etc.

Meeting the above-enumerated demands within the confines of the fighting compartment involves overcoming substantial design defficulties caused by the large size and weight of ammunition as well as the extremely limited size of a tank fighting compartment. They state that this is why the problem of automating loading on the main battle tanks of the NATO nations has not yet been solved in a practical manner.

Automatic loaders are employed on the French AMX-13 light tank and the Swedish STRV103B tank; the rate of fire of this tank's 105 mm gun is approximately 15 rounds per minute.

It is noted that the endeavor to boost the normal rate of applied fire by installing automatic loaders in tanks encountered the problem of removing spent cases from the fighting compartment. This is due to the fact that it is difficult to keep cases on board due to a tank's limited interior space. In addition, with a high rate of fire there is a sharp increase in pollution of the fighting compartment with propellant gases from the spent cases.

One way to solve this problem, in the opinion of foreign experts, is to install a special device which ejects cases through a special hatch which opens during firing. The Swedish STRV103B tank incorporates such an arrangement.

Another solution is to employ combustible cases. The advantage of such cases lies in achieving savings in short-supply material (brass) and simplicity of manufacture, as well as improvement in crew working conditions due to less fumes and no spent cases cluttering the fighting compartment.

Combustible shell cases require employment of a breech mechanism of special design. In order not to redesign the breech mechanisms of existing guns, the United States has developed, in particular for the 105 mm gun carried by the M60 tank, combustible cases with a small metal base, which produces the requisite obturation.

7. Reducing Weapon Vulnerability and Improving Crew Habitability Conditions

A tank's firepower is sharply diminished with poor weapon protection. Diminished weapon vulnerability is achieved by means of reasonable armoring of the gun as a whole as well as taking into account (during the process of design) the dynamic loads acting on weapon component parts. Particular attention should be focused on increasing antinuclear protection.

One should emphasize the exceptional significance of the dependence of tank firepower on the tank's crew habitability. Habitability is defined as the conditions in which the crew performs its duties on the march and in combat, as well as rest and performance of other vital functions while in their tank.

The nature of modern warfare demands of a tank crew great physical and emotional exertion. If a crew rapidly becomes physically tired, they lose acuity of perception of the continuously changing situation, with diminished quickness and accuracy of the system's response to external factors, increased mistakes made, in the final analysis resulting in diminished tank firepower.

The tendency of a tank crew to become fatigued can be reduced by providing a stable and natural position for the head and trunk during observation through sights and vision devices, by employing special headrests, by providing seats with height and angle adjustment, and by providing supports for the arms when the crew member is working.

Sights should be designed to ensure that the eyepiece remains in a fixed position relative to the gunner's head when the gun position changes. All sights and observation instruments should have provision for adjusting eyepiece focus. Tank gun laying should be performed by mechanical drives operated from a single control panel.

It is extremely important promptly to remove from the fighting compartment the carbon monoxide which is formed in substantial quantities by the combustion of propellant during gun and machinegun fire. The propellant gases which enter the fighting compartment together with an ejected shell case contain carbon monoxide which, depending on its concentration and duration of effect, can cause fatigue, mental depression and slowing of crew reflexes.

In order to prevent propellant gases from entering the fighting compartment from the bore, modern tanks carry a fume extractor or bore evacuator on the barrel. When a round is fired, propellant gases fill a special receiver cylinder, and subsequently are sucked from it at high velocity through angled jet apertures in the barrel. These streams of gases form a conical vacuum behind them, drawing powder fumes from the bore, which are subsequently ejected.

As a result of this bore evacuation after each round, fume pollution of the fighting compartment decreases severalfold in comparison with the situation when firing guns without fume extraction.

8. Arming Tanks With Missile and Combination Weapons

According to the views of foreign experts, potential for further increasing the power of gun artillery is becoming increasingly exhausted. In addition, substantial difficulties arise as regards mounting a gun on tanks. A gun's large weight, size, and heavy recoil dictate the necessity of employing a heavy turret. As a result the tank's weight increases, which decreases its mobility. The comparatively small size of the fighting compartment creates considerable difficulties in automating the loading process. Therefore in recent years foreign experts, in the search for ways to achieve further increase in tank firepower, have been reaching the conclusion that tanks must be armed with missile weapons -- antitank guided missiles. In the opinion of foreign military experts, ATGMs are superior to tank gun shells in target hit probability at long range. In addition, target movement has practically no influence on target kill effectiveness.

In connection with this, the idea has been expressed abroad that there is a need to develop special tank guided missiles and to employ on tanks a new weapon system consisting of guided missiles to engage tanks, machineguns to kill personnel, and a recoilless gun to neutralize hostile weapons and other targets.

The first attempts to arm tanks with manually-guided ATGMs involved the French AMX-13 and U.S. M48A2 tanks. Launchers were exterior-mounted on the tank turret and therefore were vulnerable to nuclear weapons, shell fragments and small-arms fire. The ATGM guidance system required engagement only while standing. As a consequence of this, ATGM launchers of this type were rejected for tank use.

Subsequently the endeavor to utilize the positive features of rocket-propelled and gun weapons led to the development of tanks with combination missile-gun armament. The U.S. Sheridan light reconnaissance tank and the M60A2 reinforcement tank carry such armament. On these tanks a launcher adapted to fire the Shillelagh ATGM is also employed to fire conventional shells (shaped-charge and high-explosive fragmentation).

According to reports published abroad, however, this gun is low-powered. In spite of its large caliber -- 152 mm, high-explosive fragmentation shells fired by this gun are substantially inferior in range and effect on the target to the counterpart shells fired by 105 mm and 122 mm tank guns. Development of 105 mm and 122 mm ATGMs to be fired from the barrel of existing tank guns is considered infeasible because of the inadequate damage effect on a tank by the shaped-charge warhead of an ATGM of such small caliber. The French experts who developed the Acra missile-gun weapon reached a similar conclusion.

Arming a tank with ATGMs increases its fire capabilities to hit at considerable range exposed, vertical-silhouette, both mobile and moving antitank weapons, including helicopters. At the same time foreign experts note drawbacks which hinder the extensive employment of ATGMs on tanks:

slow rate of fire, since the speed of an ATGM in flight is considerably less than that of conventional projectiles, as well as a comparatively small number of missiles carried on board, due to the fact that a missile is larger in size than an artillery shell;

ATGMs have a single role -- antitank; this is due to the fact that a considerable portion of the total weight (80-90 percent) is taken up not by the warhead but by the systems which fly the ATGM to the target and control it in flight. For this reason the missile carries only a shaped-charge warhead;

fire at inconspicuous targets (dug-in tank, ATGM, etc) is not always effective, due to the possibility that the missile will strike the ground or emplacement parapet as a consequence of the fact that in flight an ATGM executes oscillatory movements with a certain vertical amplitude;

the possibility of missile control disruption and loss during flight. This can occur because a guided missile requires that a line of sight be maintained between launcher and target. Shellbursts, smoke and dust on the battlefield can disrupt this line of sight.

In addition, high cost (a Shillelagh ATGM, for example, costs 25 to 30 times as much as a 105 mm shell) and complexity of operation have had the result that ATGMs are at the present time not in widespread use on main battle tanks. In the opinion of foreign experts, this does not mean total rejection of utilization of guided missiles on tanks; the above drawbacks of ATGMs may be eliminated to a substantial degree in the process of further research. At the present time the majority of foreign experts are of the opinion that a conventional gun with excellent ballistic characteristics will remain the principal tank weapon during the coming decade.

Chapter 3. TANK PROTECTION

Under conditions of modern warfare tank protection is secured by general layout, vehicle firepower and mobility: the smaller a tank's size, the more powerful its armament and greater its mobility, the less vulnerable it is on the battlefield. The foundation of a tank's lack of vulnerability, however, is its reliable armor protection, and therefore the main battle tanks in all countries of the world have hulls and turrets of shellproof armor.

Equipping modern armies with nuclear missile weapons, improvement of armor-piercing blast effect shells, and the widespread employment of effective shaped-charge armor piercing projectiles as well as high-explosive armor piercing shells make reliable tank protection on the battlefield difficult and make it necessary to increase demands on tank armor protection. The problem of protection is additionally complicated by the fact that the damage effect of the above-enumerated antitank weapons is based on differing physical principles, and in order to counter them armor protection requires exceptionally superior and diversified properties, which are reasonably achievable only by multiple-layer armor barriers.

1. Demands on Tank Armor Protection and Principal Ways to Achieve Them

Reliable protection of a tank crew and interior equipment against the enemy's principal antitank weapons is the most important requirement imposed on designers and engines.

Critical hull and turret components of main battle tanks are fabricated of shellproof armor steel of medium hardness, with an optimal combination of strength, hardness and toughness, which are achieved by alloying in the course of a special metallurgical process, appropriate heat treatment, by hardening the metal in rolling flat armor plates, forging and stamping armor components of complex shape.

Sufficient thicknesses b and slope angles α of front, nose and side components of turret and hull provide protection against blast effect armor-piercing shells of the principal enemy artillery systems. Sloping armor plate substantially increases its resistance to projectile penetration primarily because it increases the path of the projectile in the armor to pierce through it (Figure 2.3.1). Considering the flight of a field artillery projectile horizontal and a zero angle of projectile approach to the tank, we find from the simple trigonometric ratios of right triangle AOB that thickness b_0 of an equivalent plate taking shot at a right angle is equal to actual plate thickness b divided by the cosine of angle α of shot impact with the armor:

$$b_0 = \frac{b}{\cos\alpha}.$$

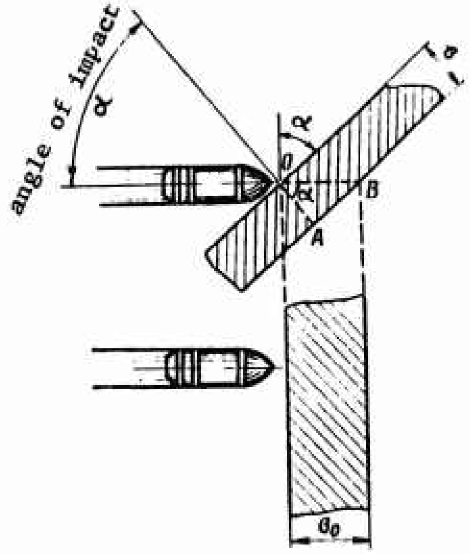


Figure 2.3.1. Effect of Armor Plate Slope Angle on Its Resistance to Shot Penetration

Consequently, the greater angle α is, the smaller its cosine, the greater is the thickness b_0 of an equivalent plate taking shot at a right angle, and the greater the shot resistance of the tank's armor component.

The multirole function of the armor protection of modern tanks makes it advisable, in the opinion of foreign experts, to employ composite, multiple-layer barriers in the design of hulls and turrets. Figure 2.3.2 shows a multiple-layer barrier which contains, in addition to steel armor plate, supplementary layers of special materials which effectively extinguish the jet of molten metal produced by a shaped-charge projectile or which attenuate penetrating radiation. By altering the compositions, mutual placement and thicknesses of the layers, one seeks to achieve the greatest tank protection against the entire aggregate of the damage and casualty-producing elements of conventional and mass destruction weapons.

Strength and rigidity of hull and turret prevent fracture, forming of cracks, residual deformations, as well as displacement of machinery and mechanisms when taking fire, by blast wave effect and the force of resistance to recoil, as a result of ramming and negotiating obstacles while traveling across terrain irregularities at high speed. The prerequisites for meeting these demands by main battle tanks are great thickness, strength and rigidity of the principal shellproof armor components of hull and turret. In addition, employed for permanent joining of principal armor components are strong welded seams with high-quality high-elasticity filler metal which does not tend to crack and which is usually relieved of dangerous shear stresses.

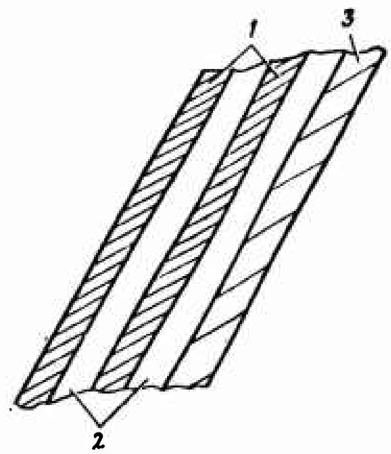


Figure 2.3.2. Multiple-Layer Armor Protection on the XM723 Infantry Combat Vehicle

Key:
1. Steel armor plate
2. Plastic foam
3. Aluminum

The under-turret hull plate, which carries the heavy turret and receives the considerable force of resistance to recoil during firing, is supported by a transverse stiffening member welded to the thick side plates. In order to increase the strength and rigidity of the entire structure, the rear plates are welded to the sides to full hull height, producing a rigid welded box.

Stamped and welded lengthwise and transverse ribs are employed to strengthen the hull floor; the stiffness of interior bulkheads, substructures and brackets is utilized, and those parts of the hull floor plate which are adjacent to the sides ("step") are sloped.

One important demand imposed on tank armor protection is to achieve the least possible weight of armor components with a specified degree of tank protection, normal placement of all interior equipment, and securement of requisite crew operation conveniences. A number of other techniques are also employed abroad to meet these demands, in addition to those discussed above: variable-thickness armor, multiple-layer armor protection, etc.

Some weight decrease with equal resistance to projectile penetration is obtained by employing steeply sloped armor plates, which sharply diminishes the armor penetration capability of blast effect and shaped-charge projectiles at angles of impact exceeding 65°.

Making the shape of welded hulls more efficient provides significant weight savings without reducing resistance to shot, but complexity of manufacture is increased somewhat (Figure 2.3.3). Cheek bevels 1 and the ship's bow shape of the nose of the IS-3 tank, with equal armor-enclosed space and degree of protection against zero angle-of-approach fire, reduce consumption of steel armor plate by approximately 0.8 ton in comparison with the simpler wedge shape of the nose of the T-54 medium tank. The sloped portion ("step") of the hull floor 3, by reducing the height of the thick side

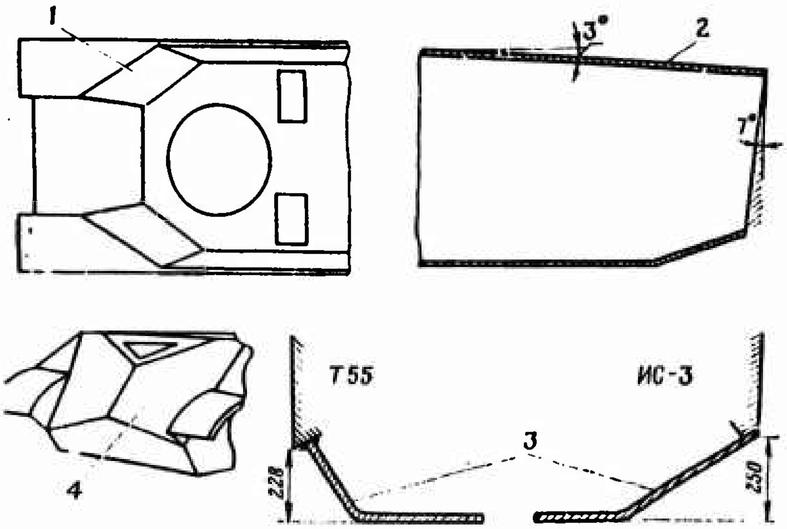


Figure 2.3.3. Making Welded Hull Shapes More Efficient

Key:

1. "Cheek" bevel on hull of heavy tank
2. Sloped roof
3. Sloped portion ("step") of hull floor
4. Ship's bow shape of nose of IS-3 tank

---

plates, reduces the weight of the T-54 tank by more than 1 ton and of the IS-3 tank by approximately 1.8 tons in comparison with analogous vehicles with a flat hull floor. A sloping hull roof plate 2 over the engine-transmission compartment, alongside an appreciable weight savings, increases allowable depression angles when firing rearward.

A tight hull and turret seal, which prevents the tank from flooding when in water, is also essential for protecting the crew and interior equipment against injury and damage by small fragments, lead splashes, combustible liquids, shock wave, toxic chemical agents, bacteriological and radioactive substances. In order to meet this requirement, solid welds are employed to ensure permanent joining of plates, sealing gaskets under removable armor plates, various seals for axles, torsion bar splines and idler cranks, and special seals for the turret ring, gun, machinegun, sight and vision device ports. It is also desirable to employ for this purpose an engine cooling system with a sealed-off airflow.

Simplicity and efficiency of hull and turret design, which reduce cost, metal and labor requirements, make it possible in wartime rapidly to set up tank production at new plants and to increase output at specialized enterprises.

One specific requirement imposed on the turret boils down to ensuring the least possible imbalance relative to its axis of rotation. In order to balance the gun and turret heavy armor protection, foreign vehicles employ large recesses in the rear of the turret, used to stow ammunition.

Important requirements imposed on the hull aim at providing the possibility of mounting a turret with a powerful gun with a large sweep radius and long recoil, as well as a suspension capable of absorbing considerable energy, essential for high-speed tanks, with considerable road wheel dynamic (additional) travel, and track drive with track support rollers.

2. Classification and Comparative Evaluation of Hulls and Turrets

Shot-resistant hulls and turrets are divided, according to method of fabrication, into cast and welded of rolled flat, curved, stamped and certain cast shaped components. The turrets of the majority of the world's tanks are fabricated by casting, while tank hulls, other than American and Swiss, are welded. The cast method of fabricating hulls and turrets makes it possible to give them the most efficient, shot-resistant, three-dimensional shape, permits considerable variation of thicknesses along hull and turret height and perimeter, facilitates the creation of multiple-layer armor barriers, and provides high structural strength and rigidity by eliminating welds and by somewhat reducing consumption of molten metal per unit of product. Drawbacks of cast hulls and turrets include less (by approximately 5-7 percent) shot resistance in comparison with rolled armor plate of equal thickness, and the necessity of custom shaping, casting and quenching equipment.

Hulls and turrets are also classified according to simplified schematized shapes. Turrets are subdivided according to this criterion into cylindrical, conical, hemispherical, and turrets with a large rear recess (Figure 2.3.4). The first two shapes, a and b, are employed in welding or riveting smallarms-proof turrets of stamped parts. The hemispherical c cast turret of the T-54 tank is characterized by a shape which offers good resistance to shellfire and ease of manufacture, but offers comparatively restricted interior space and is poorly balanced: the center of mass is displaced 180 mm forward of the axis of rotation. The large rear recess of turret d of the MBT-70 tanks increases armor-enclosed space, accommodating mechanized stowage of shells and missiles, and reduces turret imbalance, but increases overall turret weight and has a potentially dangerous shell trap between the hull and turret recess.

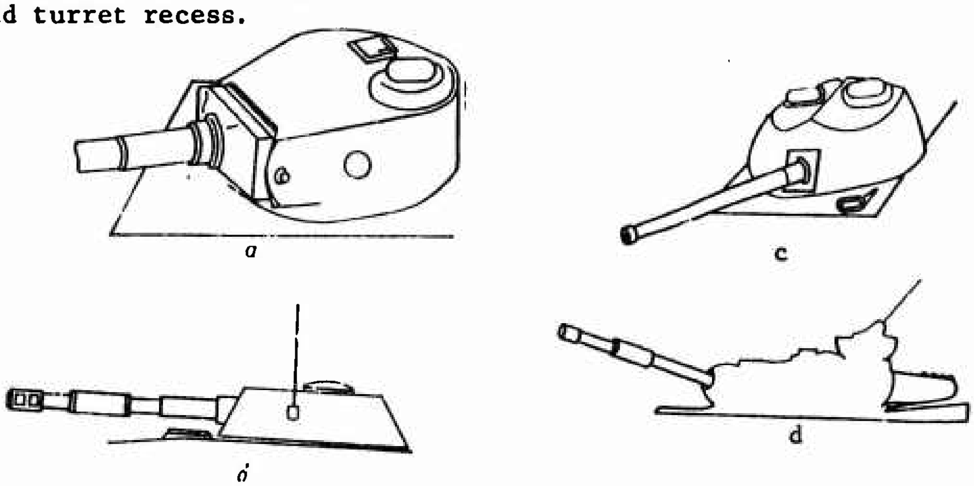


Figure 2.3.4. Schematized Designs of Tank Turrets:

a -- cylindrical; b -- conical; c -- hemispherical; d -- turret with large rear recess

Hulls are differentiated on the basis of shape of the most critical nose portion (see Figure 2.1.3), as follows: hulls with vertical armor plate in front of driver's face; ship's bow b, and wedge-shaped c, d. The former were extensively employed on old Soviet and foreign tanks, but today they are practically out of use due to pőor capability to defeat shell penetration and the complexity of welding them of three separate armor plates. Ship's bow nose b increases the angle of impact between projectile and armor by "tucking in" the glacis plates at the most probable zero angle of projectile approach, decreases probability of projectile trapping under the turret on ricochet from the glacis plates, and facilitates optimal driver placement at tank center. Foreign experts claim that drawbacks include increased complexity of manufacture, especially with multiple-layer armor protection; vulnerability of the weld of the two upper plates; need for elaborate idler wheel brackets in order for the tracks to extend to the hull nose. Wedge-shaped nose c and d, with steeply sloped armor, possesses good penetration resistance and is simpler to manufacture, especially with multiple-layer armor protection (see Figure 2.3.2); the track tensioning mechanism housing is welded directly into the hull without a special bracket. For these reasons they are extensively employed on modern tanks with welded and cast hulls.

Tank hulls can be subdivided into four groups on the basis of cross-sectional shape (Figure 2.3.5): a and b, hulls without interior recesses in the sides; c, with local recesses under the turret; d, e, f, g, with recesses above the tracks along the entire length of the hull; h and i, with recesses within the track lines. The first two groups -- a, b, c -- do not permit variable armor protection vertically and lengthwise in a welded hull, which has a negative effect on tank protection; they are characterized by a low degree of utilization of tank cross-sectional area; lacking local bulges under the turret, they make it difficult to employ the large-diameter turret ring required for heavy tank gun armament. Their advantages include small hull cross-section perimeter, which predetermines light hull weight, maximum simplicity of fabrication of a welded hull from a minimal number of rolled armor sheets, and the possibility of employing a high energy-absorbing suspension with considerable road wheel travel and track drive with track support rollers. Such hulls of type c, with a local bulge under the turret as a welded-on armor segment, are successfully employed on Soviet main battle tanks.

3. Special Measures to Improve Tank Protection Against Shaped-Charge Projectiles and Nuclear Weapons

Armored hulls and turrets of modern tanks which give protection against blast effect projectiles, in the opinion of foreign experts, fail to provide the requisite level of protection against widely-used shaped-charge armor-piercing projectiles and the casualty-producing elements of nuclear weapons. Armor thickness is not being increased to achieve better protection, since this makes a tank heavier; other means are being used.

The most common technique employed abroad to strengthen protection against shaped-charge projectiles is a skirting plate or screen which attenuates the jet of gas and molten metal on its path toward the armor. The purpose of a screen is merely to cause premature detonation of a shaped-charge projectile at the greatest possible distance from the tank's armor. A shaped-charge projectile can be detonated by a thin screen of metal sheet, strip or mesh, or even screens of thin rubberized fabric. Cost of manufacture and weight of a screen against shaped-charge projectiles are insignificant, and yet they are quite effective.

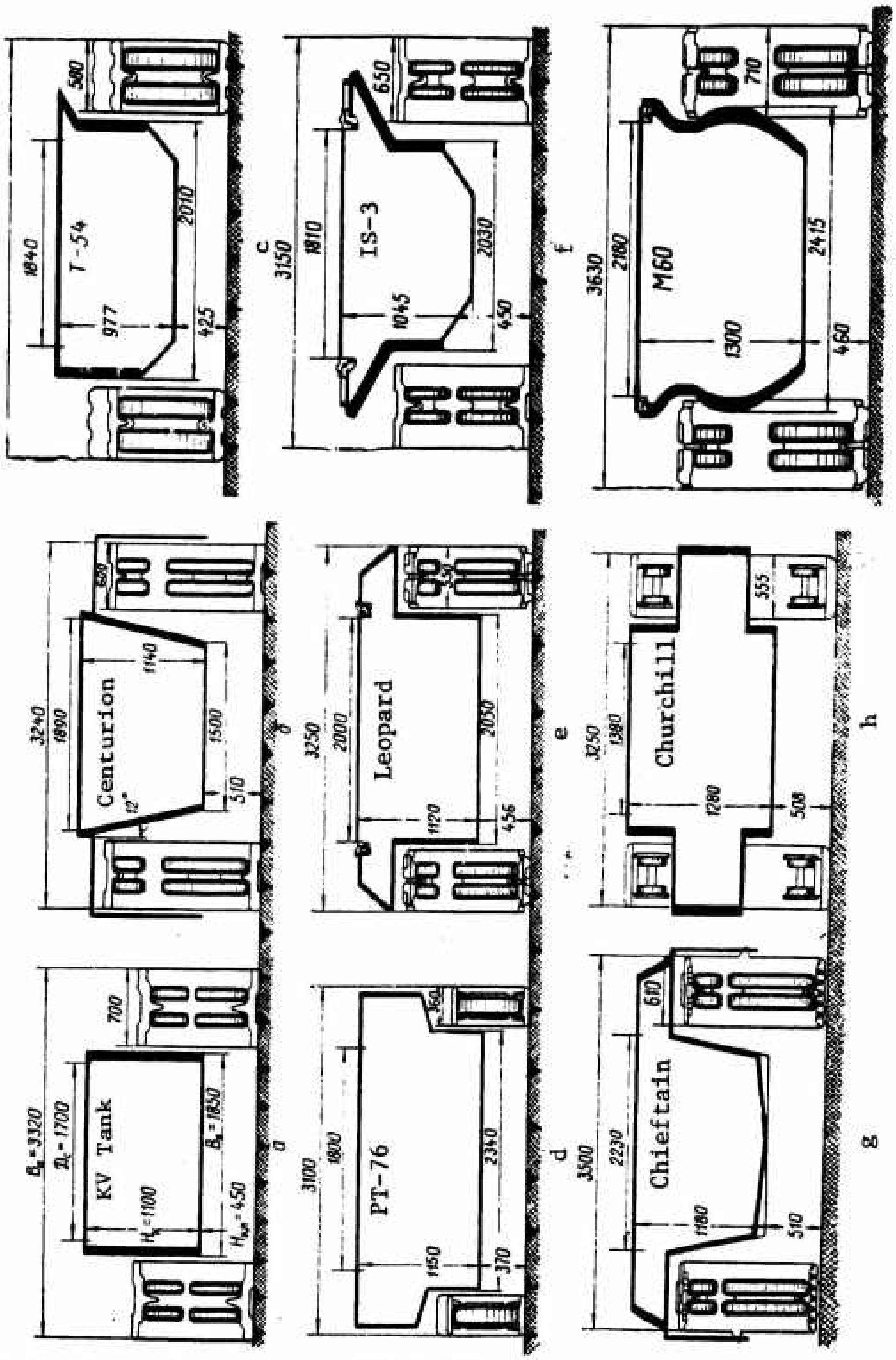


Figure 2.3.5. Cross Sections of Tank Hulls:

a, b -- without recesses; c -- with local recesses; d, e, f, g -- with recesses above tracks; h -- with recesses inside track line; i -- cast hull of M60 tank

Another promising technique for protecting a tank against shaped-charge projectile which has been discussed in the foreign literature consists in using special, comparatively lightweight metal and nonmetallic materials which possess excellent

flame-extinguishing properties against a shaped-charge jet. A combination of such materials with steel armor plate (see Figure 2.3.2) makes it possible to increase tank protection with a smaller weight increase than with solid armor construction.

Another effective means of tank protection is sloping armor. This lengthens the path the shaped-charge jet must penetrate to pierce armor, while at large slope angles (greater than 65°) conditions of formation of the shaped-charge jet worsen sharply due to deformation of the projectile at the moment of detonation.

A tank's armored hull and turret withstand well the principal casualty-producing elements of nuclear weapons, making armored troops more battleworthy in combat operations with and without the employment of nuclear weapons. Additional special weapons are required, however, to increase the antinuclear protection of tank crews.

Collective protection of crew members against blast wave and radioactive dust is provided by an antinuclear protection system. Its principal components are the following: a radiometric protection unit; devices which instantly warn of a dangerous nuclear burst; and [illegible] devices which actuate before the blast wave reaches the tank. As a result the blast wave overpressure of several atmospheres, lethal to a person not protected by armor, proves safe for a tank crew due to sealing of the tank's manned compartments. A blower-powered dust separator cleans the air centrifugally, separating and expelling 98-99 percent of the dust, and maintains in the manned compartments a slight overpressure of cleaned air. This makes it possible for tanks to operate, move and fight on radioactively contaminated terrain without radioactive dust entering the tank. New foreign tanks are also equipped with filter-ventilation units, which enable tanks to fight in conditions of bacteriological and chemical contamination of terrain.

It is difficult to protect crews from penetrating radiation, which is for the most part a gamma ray flux and a fast neutron flux. Gamma rays are attenuated by steel armor and other heavy metallic materials. For example, the lead mats on the floor of the manned compartments in some foreign vehicles are used to attenuate the dose of secondary gamma radiation on contaminated terrain. For attenuation of the fast neutron flux, foreign tank designers employ lightweight hydrogen-containing substances, and therefore layers of special antineutron materials are employed in the turret and manned portions of the hull. As a result of these measures, the radiation dose received by main battle tank crews proves to be several times less than that received by a person unprotected by armor.

Chapter 4. TANK MOBILITY

Mobility, alongside firepower and armor protection, is a most important tank combat performance characteristic. It is characterized by average speed of tank movement, cross-country performance, and running time on one fueling.

During tank operations on the battlefield tactical mobility is considered, without taking account of time required for tank fueling, servicing and maintenance. Consequently tactical mobility is defined as the average tank speed on the battlefield, which in turn depends on a tank's power-to-weight ratio and technical capabilities for its utilization.

In evaluating operational and strategic mobility, one determines average speed of tank movement from one point to another, taking into account running time on one fueling, time expended on fueling, servicing and maintenance, as well as speed limitations connected with the specific features and safety of mode of travel.

Thus mobility is determined by a tank's technical capabilities: power-to-weight ratio, type of transmission, suspension system, carried fuel supply, and performance characteristics. It is also determined by nature of movement, quality of organization of movement, physical condition and proficiency of personnel.

Increasing mobility requires first and foremost further improvement of powerplant components, transmission, tracks and suspension, and improvement of performance characteristics.

1. Tank Powerplant

The engine, together with supporting systems, comprises the tank's powerplant. Depending on the type of engine used, powerplants can be differentiated on the basis of space occupied, design complexity, and number of systems and equipment required for engine operation. For example, the gas turbine engine powerplant of some foreign tanks (XM1) is simplified as a consequence of the fact that it lacks liquid cooling and compressed air starting systems, and there is no piston compressor. When a tank is powered by a piston engine, there is no need for a gas temperature control system, heat exchanger and reduction gear. Engine economy determines the amount of fuel which must be carried in order to ensure a specified tank range.

Thus the engine is the principal and determining element of the powerplant, exerting significant influence on a tank's overall design.

Requirements on the Modern Tank Engine

The principal design characteristics, power and economy indices of a tank engine should provide the mobility specified by performance characteristics. In addition, an engine should meet a number of other requirements connected with manufacture, operation and maintenance.

One of the most important design and power characteristics of an engine is its ratio of effective horsepower to the engine's physical size. The higher this ratio, the smaller the space occupied by the engine, and the more easily it can be placed within the strictly limited space of a tank's engine-transmission compartment. Therefore a high power-to-size ratio is one of the principal requirements on a tank engine.

Design requirements also include the lightest possible weight, good balance, steady running, engine braking capability, and an engine configuration convenient for fitting in the engine-transmission compartment. The engine layout should offer easy replacement of mounted accessories and the assembled engine in field conditions.

Modern tank engines run to 383-611 kw (520-830 horsepower). In the opinion of foreign experts, however, the power-to-weight ratio of future tank engines should be at least 18.4-22 kw (25-30 hp) per ton of tank weight. Engine economy is determined by specific fuel consumption (by ratio of per-hour consumption to horsepower).

Diesel-powered tanks have a greater range than tanks with carburator engines. This is due primarily not only to smaller fuel consumption but also the greater density of diesel fuel and, consequently, larger fuel supply with equal-volume fuel tanks.

Other requirements connected with the engine operation process include good pickup, that is, capability quickly to increase and drop rpm, a high adaptability factor, minimal air consumption, and minimal heat transfer into the water and oil.

Meeting these last two requirements makes it possible to reduce the size of the air cleaner, engine coolant radiator and oil cooler. Engine exhaust gases should be as cool as possible for protection against thermal detection and heat-seeking guidance devices.

The need to maintain continuous tank combat readiness determines a number of operation requirements on an engine, such as easy cold-weather startup, reliable operation in all climatic conditions, in mountains, under water and on terrain with radioactive contamination, as well as minimal servicing time.

At the present time there is no engine which fully meets all requirements imposed on a tank engine. However, such positive diesel qualities as good economy, multiple-fuel capability (from gasoline to diesel fuel), and less fire hazard have resulted in the diesel being acknowledged throughout the world as the best tank engine. We should note that the first special tank diesel, the V-2, was developed in the USSR at the end of the 1930's. As a result of the exceptionally successful employment of the V-2 diesel on the T-34 tank in World War II, in the postwar period diesel engines began to be used on all foreign tanks without exception.

The positive experience of design and operation of V-2 engines (Figure 2.4.1) exerted considerable influence on the design of and further development trends in engines of new tanks.

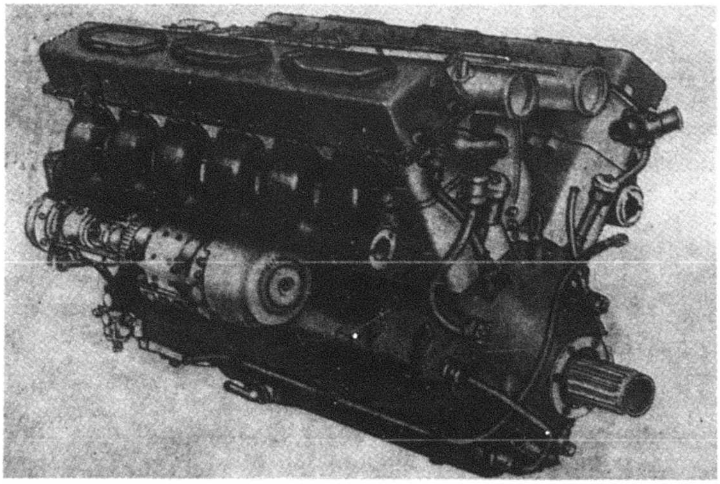


Figure 2.4.1. Type V-2 Engine

Contemporary Status of Tank Piston Engines

Almost all modern tanks produced in quantity are powered by diesel engines. The excellence of these engines suggests that they will continue to be the principal type of tank engine in coming years.

In the 1970's the NATO nation armies should have in service at least four main battle tanks: the U.S. M60A1, powered by the AVDS-1790-2A Continental engine, the West German Leopard, powered by the Daimler-Benz MB-838Ca M500 engine, the British Chieftain, powered by the Leyland L-60 engine, and the French AMX-30, powered by the Hispano-Suiza HS-110 engine.

The new Japanese STB-6 tank ("74") is powered by the Mitsubishi 10Z-F21-WT engine. The combination powerplant of the Swedish STRV103B tank includes a Rolls-Royce K-60 piston engine and a Boeing-553 gas turbine engine.

Foreign tank powerplant engineering is based primarily on building four-cycle boosted multi-fuel engines, both with direct and divided mixing.

Air-cooled engines are typical of U.S. and Japanese tanks. European countries employ exclusively liquid-cooled engines. In the opinion of experts at Daimler-Benz, liquid cooling with thermostatic regulation of fan rpm is the most economical cooling system for tank engines. The size of a liquid cooling system is not greater than that of an air cooling system, but its layout arrangement is easier, since the radiator can be placed at some distance from the engine. In addition, it is also possible to design a combined system for cooling engine coolant as well as engine oil and transmission fluid. A liquid cooling system also possesses other advantages in regard to the special operating conditions of a combat vehicle engine.

During tank operation under water, engine cooling with a liquid cooling system can be handled by immersing the radiator in ambient water. In this case duration of underwater operation is not limited by the possibility of engine overheating, and there is no need to feed air into the tank for cooling the liquid. Decreasing the required quantity of air makes it possible to reduce the diameter of the snorkel and consequently to make easier mounting and carrying. Isolating the air circuit of a liquid system reduces contamination of the engine-transmission compartment with radioactive dust when a tank is operating on contaminated ground. As a consequence of these advantages, a liquid cooling system is specified for the majority of future tank engines.

All modern tank engines are boosted. Boosting means increasing the power-to-displacement ratio, that is, horsepower per liter of engine displacement. Presently existing engines or engines designed on the basis of an existing prototype can be boosted. Supercharging is the most widely used means of boosting the power of tank diesels.

Supercharging means that precompressed air is injected into the cylinders on the intake part of the cycle. Increasing the density and weight of the charge of air makes it possible proportionally to increase fuel feed as well. As a result of this, horsepower per liter and effective engine horsepower increases without increasing the number or size of the cylinders, that is, the basic engine dimensions.

Supercharging is performed by superchargers with mechanical (Leopard, Chieftain), gas turbine (AMX-30, M60A1) and combination (STB-6) drive.

With a mechanically-driven supercharger, average effective pressure cannot exceed 0.98 MPa (10 kg/cm^2) without degrading other engine performance components. For this reason turbosuperchargers have become the most commonly used equipment; in these units the centrifugal compressor and turbine are mounted on a common shaft. Engine exhaust gases pass through the turbine blades and cause the turbine to turn, which powers the compressor. In this instance air compression is performed by utilizing the energy of the exhaust gases as they are expelled from the engine.

The amount of engine power increase obtained by supercharging depends on the pressure of the air leaving the compressor. With a pressure boost to 0.147-0.196 MPa (1.5-2.0 kg/cm^2), there occurs a moderate rise in gas temperature and pressure, resulting in a decrease in the fuel ignition delay time and roughness of engine operation diminishes.

With an increase in air pressure effectiveness of supercharging increases, but this is accompanied by a substantial increase in power and thermal loads on engine components.

An increase in air temperature with an increase in pressure leads to a rise in the average cycle temperature and an increase in thermal stress on engine components, and on the piston group in particular.

As a consequence of increased pressure, maximum gas pressure increases at the end of the compression cycle, resulting in increased mechanical loads on components of the crank mechanism. All this leads to the following: with a boost pressure greater than 0.245-0.294 MPa (2.5-3.0 kg/cm^2), special measures must be taken to ensure

engine operating capability. These measures include the following: increased intensity of cooling, improved conditions of lubrication, strengthening of crank mechanism components, as well as new design solutions making it possible to limit maximum gas pressure (piston or combustion chamber automatically regulating compression).

The majority of modern tank engines are four-cycle, although some two-cycle engines are also in use. In addition to the British Chieftain and Swedish STRV103B tanks, two-cycle engines power the U.S. Sheridan tank and the new Japanese STB-6 tank.

The less frequent employment of two-cycle engines is due to the high intensity of the engine operating process and the difficulty of ensuring reliable operation of the piston group. Engineering two-cycle engines requires considerable time, and as a rule requires design changes on the most heavily loaded components. These difficulties increase with an increase in engine power, and therefore there are no two-cycle engines among promising foreign engines of more than 736 kw (1,000 horsepower).

Modern tank engines are multi-fuel for the most part. The ability of an engine to operate on different grades of fuel -- from diesel to gasoline -- greatly facilitates the problem of fuel supply and opens up the possibility of utilizing captured fuel.

Basically only a diesel can be a multi-fuel engine, since it can cause the spontaneous combustion of any finely dispersed fuel. Carburated engines do not possess multiple-fuel capability, because they cannot operate on low-volatility heavy fuels.

The classification adopted in the FRG categorizes engines as limited multiple-fuel capability, multiple-fuel, and unlimited multiple-fuel capability. Engines in the first category are designed to operate on diesel fuel and aviation jet fuel, while those in the second category can operate on diesel fuel, kerosene, and gasoline with an octane number up to 92±1. Unlimited multiple-fuel engines can also run on high-octane gasolines, that is, on practically any fuel. At the present time multi-fuel engines most commonly occur in conformity with this classification.

The majority of four-cycle tank engines are V-type with 12 cylinders. An exception is the MB-838Ca M500 engine powering the Leopard tank, which has 10 cylinders. Well-known two-cycle tank engines have six cylinders, placed vertically or horizontally. Only the 10Z-F21-WT 10-cylinder V-type engine which powers the Japanese STB-6 tank is of a different configuration.

The V-type configuration produces the highest compactness factor, since the space between cylinder blocks can be used to place accessory equipment. In addition, some equipment can be placed on the exterior of the cylinder blocks without extending beyond the overall dimensions of the engine. Another advantage of the V-type cylinder arrangement is the high structural rigidity, which promotes decreased deformations and longer engine life.

Horizontal arrangement of cylinders permits a lower engine height, but this configuration does not provide significant advantages in regard to power-to-size ratio, because of the engine's considerable width and the necessity of placing all accessory equipment on top of the engine.

Design Features of Tank Piston Engines

The Continental AVDS-1790-2A engine (Figure 2.4.2) is a V-type air-cooled dual-turbocharged diesel.

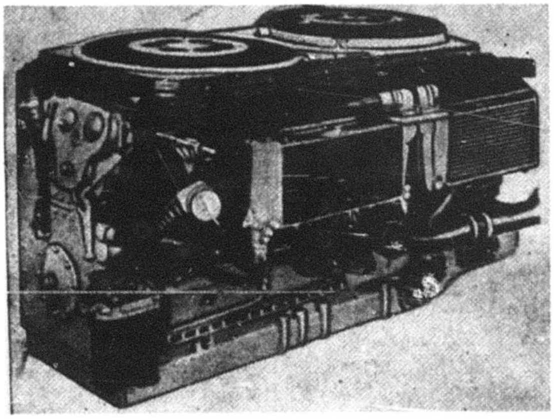


Figure 2.4.2. AVDS-1790-2A Engine

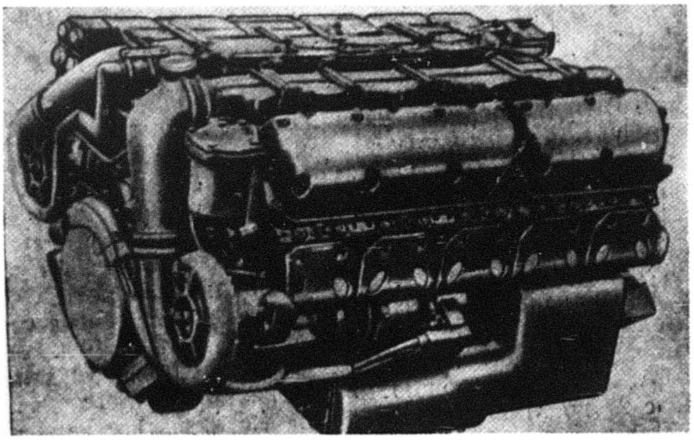


Figure 2.4.3. MB-838Ca M500 Engine

The Daimler-Benz MB-838Ca M500 engine (Figure 2.4.3) is of the MB-837 type-size series, which includes 6, 8, 10 and 12-cylinder diesels ranging from 295 to 810 kw (from 400 to 1100 horsepower). The V-type design of the cylinder block-crankcase is highly compact and rigid. The stationary components of the crank mechanism are manufactured of high-strength lightweight alloy. Each cylinder has its own individual removable cylinder head with precombustion chamber and wet cylinder liner.

All accessories and tanks required for engine operation (oil tank, engine coolant and oil preheater, etc), as well as both turbochargers, generator and starter are mounted on the cylinder block-crankcase. Fuel consumption at maximum speed runs 165 liters per hundred km.

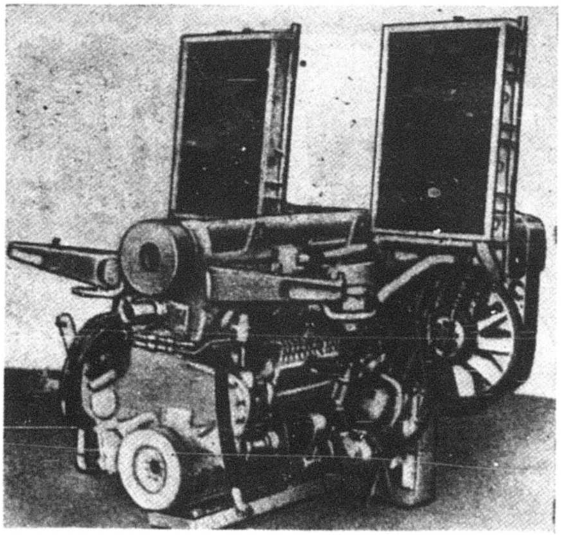


Figure 2.4.4. Two-Cycle L-60 Engine

The Leyland L-60 two-cycle engine (Figure 2.4.4) has a vertical cylinder configuration. Each cylinder contains two pistons which move toward each other. The upper pistons, which control opening of the exhaust ports, are connected to a crankshaft located in the upper part of the engine. The lower pistons, which control opening of the intake ports, are connected to a crankshaft in the lower part of the engine. Both shafts are connected by a gear train, which synchronizes rotation of the shafts and integrates the torques of the upper and lower shafts.

The modernized Chieftain tank (Mk 5) is to be powered by the L-60 4Mk7A engine, which develops 596 kw (810 hp) at 2250 rpm, which is a modification of the series-produced L-60 4Mk5A engine. The horsepower per liter of the modified engine has been raised from 27 to 31 kw/l (from 36.8 to 42.6 horsepower per liter) and is the highest of all foreign series-produced tank engines. A complete tank engine replacement can be performed in four hours.

The Hispano-Suiza HS-110 engine (Figure 2.4.5) is a four-cycle swirl-chamber diesel with opposed cylinders. The engine can operate on diesel fuel, kerosene and gasoline. The shift from one fuel to another is made by turning an index-marked knob linked to a rack stop. The swirl chamber design facilitates achieving multiple-fuel capability.

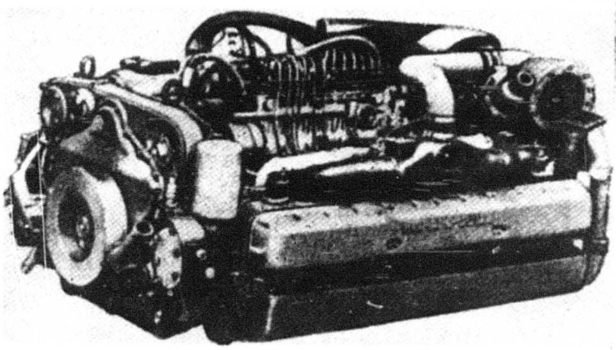


Figure 2.4.5. HS-110 Engine

The K-60 two-cycle engine powering the Swedish STRV103B tank is similar in design to the British Chieftain tank's L-60 engine. Initially the engine was built to develop maximum output of 177 kw (240 hp). Turbocharging was subsequently added, resulting in boosting output to 221 kw (300 horsepower).

A comparison of the Soviet V-55 diesel tank engine with series-produced foreign tank engines shows that it is inferior in power-to-size ratio only to the MB-838Ca M500 engine of the Leopard tank and is superior to all two-cycle engines. In spite of a moderate power-to-displacement ratio, the power-to-size ratio of the V-55 engine is fairly large, achieved by employing small accessories and a carefully designed layout of the engine proper. As a result of this, the compactness factor of the V-55 engine is high (33.2 $1/m^3$), a figure which has not been achieved in any foreign-built engine.

Moderate engine operation figures and excellence of design ensure long, trouble-free operation of Soviet tank diesels.

Future Foreign-Built Piston Tank Engines

An increase in tank power-to-weight ratio to 18.4-22 kw (25-30 horsepower per ton) requires a further increase in the power output of tank engines.

Future tank engines will be boosted by turbocharging in combination with intermediate cooling of the air entering the engine's cylinders. The increased density of the cooled air makes it possible to increase quantity of fuel injected and substantially to increase engine power. In addition, cooling the air reduces the thermal stress on engine components and reduces the quantity of heat removed by the cooling system. This makes it possible to reduce radiator size and to decrease power expended on driving the engine fan.

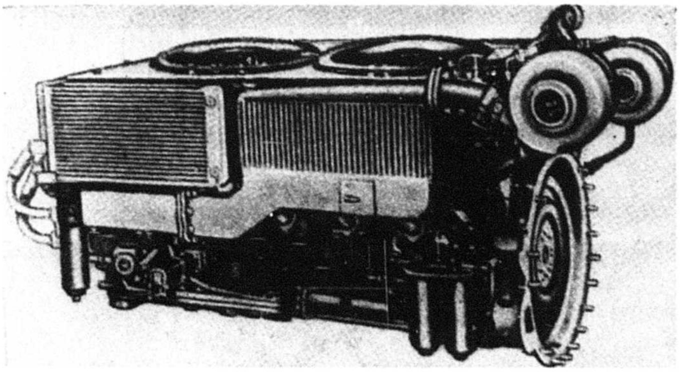


Figure 2.4.6. AVCR-1360 Engine

Alongside these positive aspects, however, employment of turbocharging makes it necessary to limit mechanical loads on engine components, especially at the high turbocharging pressures typical of future engines. Calculations indicate that with a boost pressure of 0.294 MPa (3.0 kg/cm^2) and air cooling by 30° in an engine with a compression ratio of 20.5 operating at full load, maximum gas pressure in the cylinder can reach 19.6 MPa (200 kg/cm^2), which is beyond the pressure permitted on the basis of strength of engine components.

This pressure can be reduced by dropping the compression ratio, but this results in harder starting for multi-fuel engines, with rougher light-load operation. Therefore the compression ratio should be variable, remaining high during startup and engine operation under partial load, with compression brought down for full-load operation.

Such a principle was employed by engineers on Continental's AVCR-1360 (Figure 2.4.6), a promising U.S. tank engine, with a piston which automatically regulates the compression ratio.

Employment of such a piston makes it possible to vary the compression ratio from 10 to 22:1, as a consequence of which average effective pressure in the AVCR-1360 engine is 1.74 MPa (17.8 kg/cm^2), while the power-to-displacement ratio is 40.8 kw/l (55.4 hp/l). Other design features of this engine include two-stage boost with a turbocharger in the first stage and a Roots supercharger in the second stage. Air is cooled in an air cooler. The cylinder blocks are positioned at an angle of 120°. It is reported that the engine starts up readily at ambient air temperatures raging from -45 to +52°C and does not lose power at elevations up to 3,000 meters above sea level.

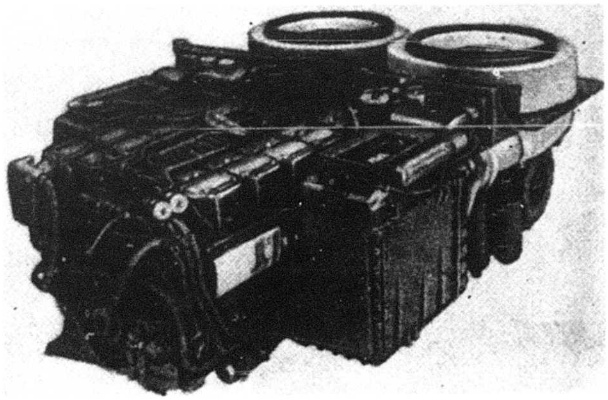


Figure 2.4.7. MB-873Ka500 Engine

Hispano-Suiza, which builds engines for the French AMX-30 tank, is also working on additional boost for the HS-110 engine by increasing boost pressure. In order to limit maximum combustion pressure, company engineers have designed a swirl chamber with automatic volume control. On the basis of test results, company engineers plan to increase the power of an engine with swirl chamber automatic volume control to 883 kw (1200 hp) at 2400 rpm. Average effective pressure in a boosted engine will be 1.54 MPa (15.7 kg/cm^2), and the power-to-displacement ratio will be 31 kw (42 hp/l).

Mercedes-Benz has developed the MB-873Ka500 engine (Figure 2.4.7) for the Leopard 2 tank, which is to replace the Leopard 1 tank currently in service with the Bundeswehr. This engine is a member of the MB-870 "family" of engines, together with 6, 8, and 10-cylinder models.

In contrast to the MB-837Ca M500 engine, the new engine has two turbochargers, and crankshaft rpm at maximum horsepower has been boosted to 2600 rpm. The need to

limit average piston speed, which is 13.5 mps, required shortening the piston stroke to 155 mm. Increasing the total number of cylinders and boost have made it possible to increase engine output to 1104 kw (1500 horsepower) with a fairly high power-to-size ratio of 659 kw/m^3 (895 hp/m^3). The MB-800 "family" of 6, 8, 10, and 12-cylinder engines, ranging from 368 to 736 kw (500-1000 horsepower), has been developed for future Bundeswehr light amphibious air-transportable tracked vehicles. All engines of this series are boosted to 3,200 rpm and therefore have better power-to-size and specific weight ratios. Each engine has one turbocharger. It is reported that all engines of the MB-870 and MB-880 family have limited multiple fuel capability, are suited for operation in arctic and tropical climate conditions, start up readily at low temperatures and operate well at high angles of slope.

All engines of the MB-870 family have the same average effective pressure figure of 1.53 MPa (15.65 kg/cm^2) and power-to-displacement ratio of 30.9 kw/l (42 hp/l), while all engines of the MB-880 series have figures of 1.33 MPa (13.6 kg/cm^2) and 33.1 kw/l (45 hp/l) respectively. These engines' moderate boost makes it possible to manage without special design measures to limit maximum gas pressure in the cylinder.

In connection with difficulties involved with boosting two-cycle engines, the British firm Rolls-Royce has stopped any further work on designing such engines and is developing for the Chieftain tank the new 12TCA 12-cylinder 4-cycle diesel, developing 828 kw (1125 hp). This engine has a turbocharger with intermediate air cooling and a high-temperature cooling system.

A perusal of future tank engines indicates that they are being designed on the basis of different principles. U.S. engines are characterized by very high boost and relatively low compactness factor values. In contrast to this, engines designed in the FRG and a number of other countries are distinguished by high compactness factor values and lower boost, which would suggest high reliability of these engines.

Prospects for Employment of Gas Turbine Engines in Tanks

Gas turbine engines, just as piston engines, are internal-combustion heat engines. The principle of operation of the gas turbine engine working cycle, however, is distinguished by the fact that the various processes of the cycle take place continuously in different parts of the engine: air intake and compression in a compressor, fuel combustion in a special chamber, and expansion of gases in turbines. The compressor and turbine rotors, which perform only rotary motion, are the engine's moving parts. The absence of reciprocating moving parts enables the engine to operate at a very high rpm, which is limited solely by the mechanical strength of the compressor and turbine disk and blades. High velocities make it possible to design a compact engine with a high power-to-size ratio. This is one of the reasons for the considerable attention being devoted at the present time to the development of tank gas turbire engines.

As is noted by foreign experts, employment of gas turbine engines can also provide a number of other advantages increasing the combat effectiveness of tanks. A turbine is easy to start up in lcw-temperature conditions and does not have to be warmed up after startup. As engine rpm drops with a load increase, the torque of two and three-shaft gas turbine engines steadily increases, which makes it possible

to reduce the number of gears and simplify the transmission. The engine is extremely simple in operation and can be more easily adapted than a piston engine to operate on different fuels. Less power is required to cool a gas turbine than a piston engine. Oil consumption is also considerably less, since there is no possibility of oil entering the combustion chamber. While superior to piston engines in all the above respects, gas turbine engines are considerably less economical than diesels. The reason for this is that the turbine blades are subjected to the continuous effect of a stream of incandescent gases. It is rather difficult to provide reliable cooling of turbine blades, as they are fairly thin and as a consequence of the extremely high rpm of the rotor with its blade rim. Therefore it is necessary to limit the temperature of gases entering turbines. This results in lower engine efficiency and increased specific fuel consumption.

Foreign-built gas-turbine engines consume considerably more fuel than a diesel engine of equal power. Since a decrease in gas temperature is achieved by raising the excess air ratio, new difficulties arise, connected with the necessity of filtering air, consumption of which is several times greater for these gas turbine engines than for a diesel of equal power. The increased air consumption also complicates submerged operation of tanks powered by gas turbine engines. Another drawback of the gas turbine engine is the significant relationship between engine power and ambient temperature and pressure.

Thus today's gas turbine engine cannot yet compete with the tank diesel in a number of indices, but chiefly due to the high fuel consumption and consequently shorter tank range. Therefore principal efforts in development of future tank gas turbine engines are focused on improving engine economy.

In order to resolve this problem it is necessary first of all to raise gas temperature at the turbine inlet, which ranges from 1000 to 1100°C in today's best foreign-built gas turbine engines. A further boost of this temperature requires effective blade cooling which, as pointed out, presents a difficult problem.

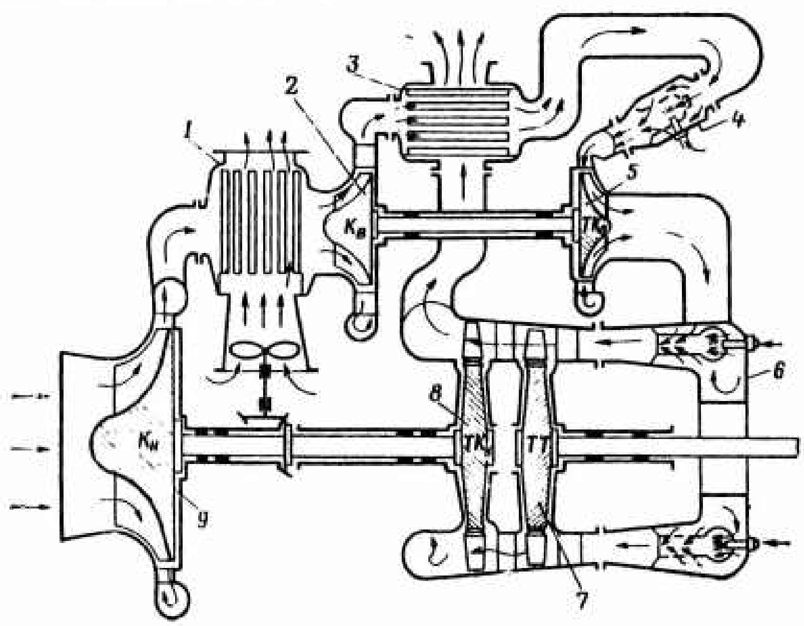


Figure 2.4.8. Schematic Diagram of a Three-Shaft Gas Turbine Engine

Key to Figure 2.4.8 on preceding page:

1. Cooler
2. Compressor
3. Heat exchanger
4. Main combustion chamber
5. Compressor turbine
6. Supplementary combustion chamber
7. Output turbine
8, 9. Compressor chambers

It is a simpler matter to improve economy by utilizing heat from the engine exhaust gases. Special devices are employed for this -- heat exchangers. Preheating air in a heat exchanger makes it possible to reduce the quantity of fuel which must be fed into the combustion chamber to heat gases to the requisite temperature. The size of heat exchangers, however, proves to be close to that of the engine itself, and therefore in utilizing heat exchangers a gas turbine engine loses one of its advantages -- compactness. We should note that with an increase in gas temperature at turbine inlet and with utilization of complex gas turbine engine layouts, the size of the heat exchanger could be substantially reduced.

Many countries are working on development of tank gas turbine engines, with the United States furthest advanced in this field. Figure 2.4.8 contains a diagram of a gas turbine engine design (Ford-705).

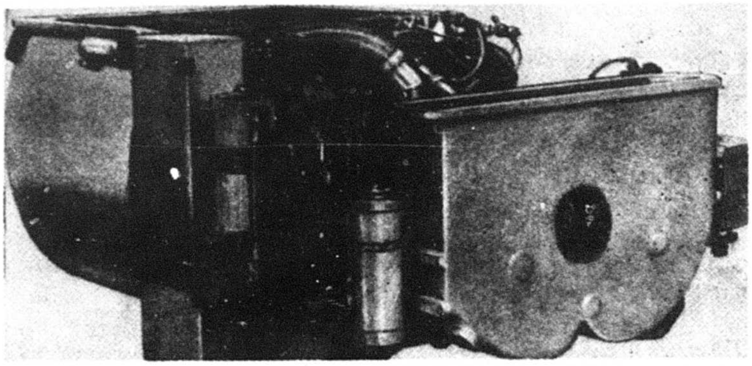


Figure 2.4.9. AGT-1500 Engine

By 1971 Lycoming had built 19 experimental models of a gas turbine engine, which was given the designation AGT-1500 (Figure 2.4.9). In view of stringent requirements on power-to-size ratio, the company somewhat simplified the engine design in comparison with the Ford-705 engine. They eliminated the intermediate air cooler and additional combustion chamber.

This engine was tested on an M48 tank; these tests demonstrated the engine's capability to work under realistic operating conditions. A minimum specific fuel consumption of 0.260 kg/kw/h (191 g/hp/h) was achieved at a 70 percent load. At maximum power specific fuel consumption was 0.284 kg/kw/h (209 g/hp/h), and at 50 percent load -- 0.290 kg/kw/h (213 g/hp/h).

The only tank currently in service to be powered by a gas turbine engine is the Swedish SRTV103 tank, which is also powered by a K-60 two-cycle diesel. Initially the tank was powered by a 184 kw (250 hp) Volvo DRGT-1 gas turbine, which was later

UNCLASSIFIED

AD NUMBER

B102 932

CLASSIFICATION CHANGES

TO

FROM

AUTHORITY

USAITAC ltr
7 Mar 89

THIS PAGE IS UNCLASSIFIED

replaced with a 243 kw (330 hp) Boeing-502-10MA engine. At the present time the tank carries a 361 kw (490 hp) Boeing-553 gas turbine engine without heat exchanger. The tank powerplant is set up so that the gas turbine automatically cuts in when the diesel engine reaches maximum power. When necessary, either engine can be fired up, or both simultaneously. When both engines are operating, torque is transferred through a mechanical gearbox, and through a torque converter when just the K-60 engine is operating. Actual torque when starting up from a dead stop and utilizing the gas turbine engine is almost six times the rated torque.

In developing this combination powerplant, engineers were figuring on only periodic gas turbine operation, when diesel engine power output is inadequate. In this case gas turbine fuel consumption will not be high, and requirements on degree of air filtering can be reduced.

Prospects for Using Wankel Engines in Tanks

The rotary piston engine designed by the German engineer Wankel continues to attract the attention of designers with the possibility of building a tank engine which has a high power-to-size ratio, is simple in design and operation, with no vibration and a low noise level.

Foreign publications have described development of such engines. At the beginning of the 1970's Rolls-Royce built and tested an experimental two-stage rotary-piston diesel which, it is believed, could replace the L-60 two-cycle engine in the Chieftain tank.

In 1973 a report appeared in the Australian press on development of a so-called "orbital" engine which is a rotary engine in principle but, in contrast to the Wankel engine, the piston describes a plane-parallel, "orbital" movement in a cylindrical plane of the engine body.

Prospects for employment of such an engine for tanks is considered improbable at the present time due to difficulty in performing a diesel cycle with this engine and insufficient experimental confirmation of operational reliability.

Tank Powerplant Auxiliary Equipment

The principal requirements on powerplant accessory equipment are compactness, reliability, simplicity and convenience of servicing, and capability of rapid removal and installation in field conditions.

In order to reduce volume, one frequently combines some powerplant accessory equipment in a single unit with the engine. For example, oil coolers, oil tank, and engine coolant preheater are mounted on the MB-838Ca M500 engine, while the engine itself is unitized with the transmission. Cooling system fans and oil coolers are mounted on the engines of the U.S. M60A1 and Japanese STB-6 tanks. The L-60 engine forms a block unit with its engine coolant radiators and fans. Although the power-to-size ratio of the accessory-mounted engine becomes less, the total volume taken up by the powerplant is reduced. Length of lines is reduced, and disassembly-assembly work in engine replacement is simplified.

One way to reduce the volume of space occupied by cooling system equipment is to shift to high-temperature cooling systems, in which the temperature of the coolant leaving the engine block can reach 120-125°C. Increasing the temperature differential between the liquid and air in the radiator ensures more intensive cooling and makes it possible to reduce the size of radiator and fan.

Considerable advantages are gained by employing forced cooling systems, in which exhaust gas energy is utilized to generate airflow in the radiator. This increases engine economy. A drop in exhaust gas temperature reduces the level of thermal radiation from the tank hull. The system proves to be very simple and reliable, since it contains no moving parts. Placing the radiator in an isolated ejector compartment prevents dust-laden air from entering other tank compartments, and during submerged operation reliable engine cooling is achieved by immersing the radiator in ambient-source water.

In connection with increasing the circulating flow of oil in boosted engines, high-output centrifugal filters are extensively employed for cleaning the oil, filters distinguished by compactness, a high degree of filtration, constant resistance which is independent of degree of filter fouling, and capability to operate for an extended period of time without cleaning.

The engine starting system exerts considerable influence on the size of a powerplant. Electric starting of large-output diesel engines is becoming increasingly more difficult in connection with the limited capacity of storage batteries. Therefore compressed air is frequently used as the principal means of engine starting; compressed air is fed into the engine cylinders during startup. In this arrangement the powerplant includes a compressor to charge air tanks.

It is becoming increasingly common to add an auxiliary motor in the engine compartment, used to drive the generator which charges the storage batteries and operates all electrical accessories when the engine is not operating.

An auxiliary motor can be used to warm up and start up the main engine, and in certain instances to move the tank short distances.

The Leopard and Chieftain tanks carry auxiliary piston engines. A single-shaft gas turbine engine, however, which is highly compact and lightweight, is considered to be the best engine for this purpose. The engine's poor efficiency is of no importance due to the brief time of operation and the possibility of utilizing the thermal energy of the exhaust gases to preheat the main engine.

ultimately such a self-contained unit may replace the currently-used injector-type preheaters which, in spite of their advantages, require considerable electric power.

2. Tank Transmission

Tank transmission is defined as the aggregate of devices which connect the engine crankshaft to the driving sprockets of the track drive. It transfers energy from engine to track drive, converts and redistributes engine torque between tracks.

The principal function of a tank transmission is to change the tractive efforts and speeds of straight-line movement and to turn the tracked vehicle. In conformity

with this role, any tank transmission should include as a minimum a gearbox and steering mechanism or a power transfer and steering mechanism, and final drive in order to reduce their power load, size and weight.

The most important demands on a transmission, proceeding from its function, reduce to the following: excellent tank tractive performance during straight-line movement and turning, providing high vehicle top and average speeds; simplicity and ease of tank control, eliminating complexity of driver training and rapid tiring; lightweight and especially small size of equipment; inexpensive manufacture; ease of servicing and maintenance; high operational reliability and efficiency.

Tank transmissions are subdivided into mechanical, hydromechanical, and electromechanical on the basis of mode of transferring energy and method of variable conversion of engine torque (Figure 2.4.10). Thus transmission type is determined by the design of the gearbox which converts engine torque.

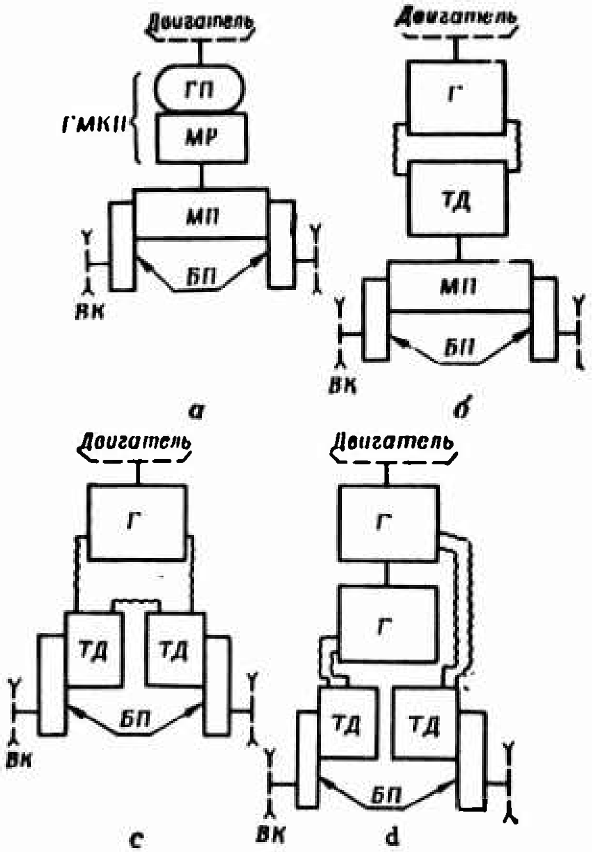


Figure 2.4.10. Block Diagram of Transmissions of Foreign Tanks:

a -- hydromechanical; b, c, d -- electromechanical; двигатель -- engine; ГП -- complex hydrodynamic transmission; MP -- mechanical reduction gear; МП -- steering mechanism; БП -- final drive; BK -- driving sprocket; ГМКП -- hydromechanical gearbox; Г -- generator; ТД -- traction motor

Transmissions with mechanical gearboxes which contain only pinion drives and clutches are called mechanical transmissions. Their widespread use on all

series-built Soviet and many foreign tanks is due to important advantages of mechanical transmissions: high efficiency across a broad range of gear ratios; considerable compactness and relatively light weight; comparatively low cost of manufacture and sufficient available manufacturing capacity; simplicity of field repair and factory overhaul.

A disadvantage of mechanical transmissions is the stepped change in gear ratios and significant gear-shifting time, which leads to underutilization of engine power, lower average vehicle speed, and diminished tank pickup and agility. Vehicle operation is comparatively complicated and difficult, due to frequent shifting of gears. In addition, the rigid kinematic link between engine and track drive has a negative effect on dynamic loading of engine and transmission, and reduces the reliability and durability of transmission components.

Improvement of the mechanical transmissions of today's tanks is directed toward diminishing the influence of these drawbacks. In order to improve vehicle pickup and boost average tank speed, one increases the number of gears within certain limits, and reduces gear shifting time, employing synchronizers or individual clutch engagement in simple gearboxes, or replacing them with planetary gearboxes. To improve agility, improved steering mechanisms are employed, changing to double-flow power transfer and steering mechanisms, replacing clutch-and-gear with hydraulic steering mechanisms. The latter are employed on several foreign vehicles (STRV103B, P61, Marder) and make it possible smoothly to adjust a tank's turning radius without slipping of clutches or brakes.

Hydraulic servo mechanisms, which are in widespread use, are another radical means of facilitating tank operation. To improve the operating reliability of mechanical transmissions, release links are provided (usually these are master clutches), sometime engine torsional oscillation dampers are employed, and more reliable clutches and brakes operating in oil are being adopted.

Hydromechanical is a term applying to transmissions with hydromechanical gearboxes containing a complex hydrodynamic transmission* and a three-five gear mechanical reduction gear, including reverse. The steering mechanism and final drives are the same as in mechanical transmissions. Employment of hydromechanical transmissions on U.S. and West German tanks is due primarily to the fact that these transmissions are automatic. They provide continuous (stepless) and automatic (without driver intervention) change in transmission gear ratios and tractive force on the tracks in conformity with resistance to tank movement. Foreign experts consider the following to be advantages of a hydromechanical transmission: considerably easier tank operation, increased reliability and service life of piston engine and transmission due to filtration and partial extinguishing of torsional oscillations, clipping of dynamic load peaks, reduced slipping of clutch devices when a tank is starting up from a dead stop and during changing of gears. All this is achieved

---

* A hydrodynamic transmission operating under conditions of heavy loads and low turbine wheel speeds as a torque converter and automatically shifting to hydraulic clutch mode as load decreases and turbine wheel speed increases, is designated complex.

due to the fluid coupling between the hydraulic transmission impeller and turbine provided by a flow of oil.

One serious drawback in their opinion is the low efficiency of hydrodynamic transmissions, due to which vehicle top speed and range are reduced, and a special elaborate transmission cooling system is required as a consequence of the considerable heat release. The limited range of automatic change of tank tractive force with a satisfactory hydraulic transmission efficiency and the complexity of reversing it make an additional mechanical reduction gear absolutely essential. The need for a cooling system and a complex mechanical reduction gear increases the volume and weight of a hydromechanical transmission, which complicates its employment in tanks with a closely-packed engine-transmission compartment layout.

The term electromechanical is applied to transmissions with electrical machines: generators and traction motors (Figure 2.4.10b, c, d). Foreign experts believe that the above-enumerated advantages of hydromechanical transmissions are also characteristic of transmissions of this type; Layout possibilities are improved due to the simplicity of transmitting electric power a certain distance, since transmission of electric power can assume any spatial form. The generator can perform the function of starter to start up the engine on storage batteries. Electromechanical transmissions have not been used on series-built postwar tanks, however, due to their considerable size, and especially due to the large number of electrical machines and startup and control devices as well as short supply of electrical conducting materials.

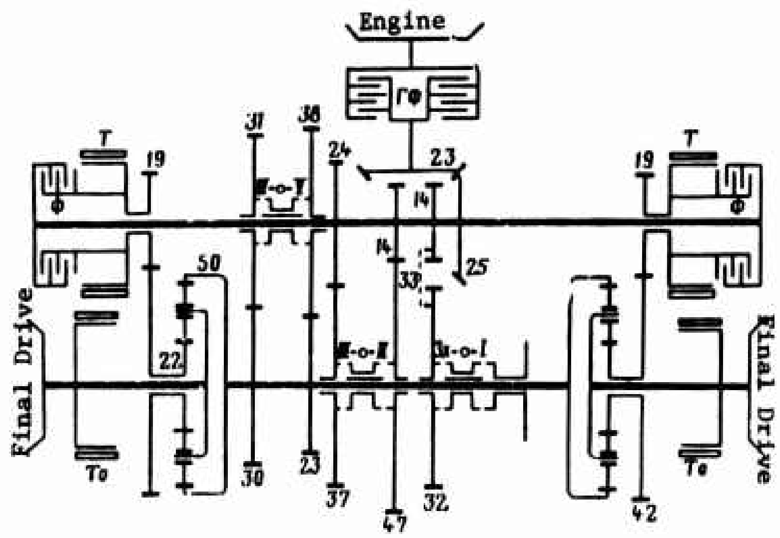


Figure 2.4.11. Kinematic Diagram of Double-Flow Transmission and Steering Mechanism of the ATL Light Artillery Tractor

---

Tank mechanical and hydromechanical transmissions are additionally subdivided on the basis of structural layouts into single-flow and double-flow, which include a double-flow transmission and steering mechanism. The latter are distinguished by the fact that power from engine to track proceeds along two paths following a splitting shaft. The main power flow passes through the gearbox change gears to

the epicycles of the integrating planetary gear sets, while the remaining power passes through supplementary drive gears to the sun gears of the planetary sets.

Total power is directed from the planet pinion carriers to the tracks through the final drives. The gear ratios to the sun gears of the left and right side are identical during straight-line movement and are different when turning. This causes change in track speeds and causes the tank to turn.

The widespread use of double-flow transmissions (Figure 2.4.11) is due to their considerable advantages. The transmission consists only of three units: the transmission and steering mechanism, and two final drives, which increases compactness of engine-transmission compartment layout, simplifies tank assembly and transmission routine servicing, reduces the number of seals and work involved in mutual alignment of equipment. In addition, tank agility is improved by the variable magnitude of calculated turn radii, which increase with transition into the higher gears, and tank turn capability on its center of gravity. Vehicles with double-flow transmission and steering mechanism which have a hydraulic torque converter in the supplementary drive, have the greatest agility.

3. Tank Running Gear

A tank's running gear includes suspension and track drive. The running gear is a critical, heavily-loaded and the least protected element of the tank.

Tank suspension includes components, assemblies and mechanisms linking the vehicle hull with the road wheel axles. In order to soften the jolts taken by the road wheels during tank movement across terrain irregularities, tank suspension mandatorily includes a flexible element -- springs. Hydraulic shock absorbers are installed on modern high-speed tanks to accomplish rapid damping of tank hull oscillations on a flexible suspension and to absorb impact energy. The performance of a tank's suspension determines to a considerable degree crew fatigability, average speed, accuracy of fire while moving, reliability and service life of vehicle assemblies, mechanisms, instruments and equipment.

Improvement in tank suspensions aims at ensuring smooth vehicle movement, permitting maximum speed possible on the basis of tank tractive force on roads, cross-country roads, and terrain. This condition is difficult to fulfill with today's high-speed tanks with a high power-to-weight ratio. To increase smoothness of tank travel, every effort is made to increase road wheel full and dynamic travel, increasing suspension energy-absorbing capability and reducing probability of suspension "bottoming": jolting road wheel arm rubber stop impacts, causing excessive hull vertical accelerations. Tank designers employ soft suspensions with a long (1.1-1.5 second) period of tank natural longitudinal-angular oscillations and non-linear antiresonance characteristics. Numerous hydraulic shock absorbers are employed, which provide rapid damping of tank hull oscillations, on a flexible suspension and flexible road wheel arm retainers, which prevent jolting road wheel arm impacts onto the tank hull.

The overwhelming majority of modern Soviet and foreign-built tanks (Figure 2.4.12) feature individual torsion-bar suspension, the advantages of which include simplicity of design, reliability of splined connection between torsion bar, hull and road wheel arm, torsion bar protection against combat damage, and minimal

suspension system operational maintenance requirements. Coil spring suspensions were employed primarily by British tank designers, and the only modern tanks employing them are the Centurion and Chieftain. Practically no other suspensions with elastic metal material are being employed today. All tank-building countries, however, are showing considerable interest in pneumatic suspension, which is already employed on several series-produced vehicles, including on a new Japanese tank.

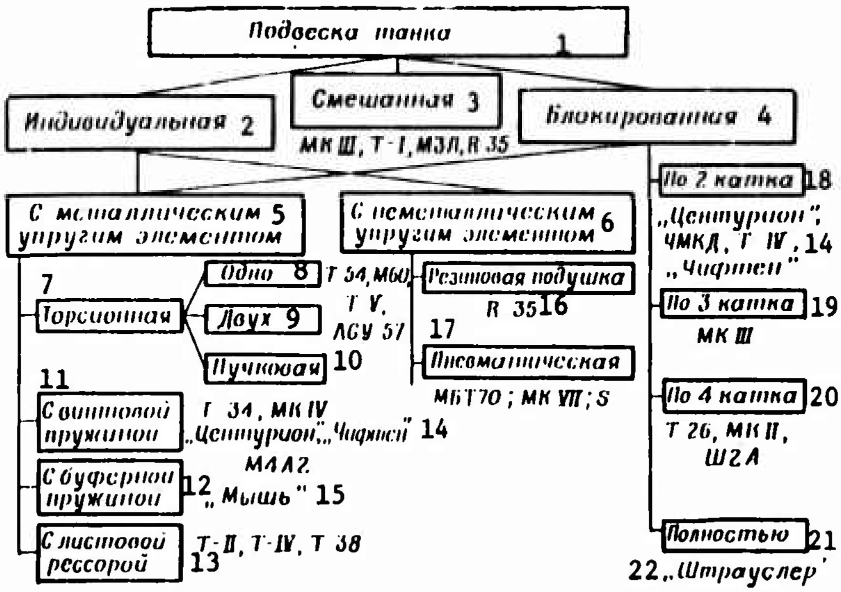


Figure 2.4.12. Tank Suspension Classification Diagram

Key:

1. Tank suspension
2. Individual
3. Combined
4. Multiple-wheel
5. With metal flexible element
6. With nonmetallic flexible element
7. Torsion bar
8. One
9. Two
10. Bundle
11. With coil spring
12. With buffer spring
13. With leaf spring
14. Centurion, Chieftain
15. Mouse
16. Rubber pad
17. Pneumatic
18. Two road wheels
19. Three road wheels
20. Four road wheels
21. Fully
22. Straussler

Advantages of pneumatic suspensions will include optimal nonlinear characteristics $P_k=f(f_k)$, large road wheel full and dynamic travel, low relative weight, possibility of various placement of pneumatic springs, including without utilization of precious tank armor-enclosed space. Shortcomings include complexity of design and increased volume of routine servicing procedures on pneumatic suspension, as well as susceptibility to temperature effects.

Hydraulic shock absorbers, required for high-speed tanks with metal suspensions, are subdivided by design into blade-type (T-54 and T-55 tanks), articulated

suspension-piston type (PT-76), and piston direct-acting (BMP-1). The latter are the most highly durable, best designed from a manufacturing standpoint, and provide stable operation, but are fairly unwieldy and are difficult to incorporate on a tank.

The end of a vehicle's propulsion chain is those components which directly interact with the environment to create the external tractive force which moves the vehicle. Tanks employ only track drive, which is simple in design, compact and has low battlefield vulnerability, and gives tanks greater cross-country performance and agility than other types of arrangements -- wheeled, half-tracked, ski half-tracked, screw-conveyer type, etc.

Drawbacks of track drives include poor durability, poor efficiency, large relative weight and considerable operational servicing and maintenance, great number of component assemblies and mechanisms -- drive sprockets, tracks, road wheels, track support rollers, track tensioners with idler wheels, mud removers, as well as compensating devices on U.S. tanks.

An endeavor to extend the service life of the tank track drive resulted in employment, alongside the conventional track, of tracks with rubber-and-metal link (Figure 2.4.13). This linking arrangement has a service life several times that of the open type, because the sliding friction of metal on metal in an abrasive environment, typical of the open-type track link, is replaced by the internal friction of deforming layers of rubber. Steel sleeves 2, 4, and 5 with rubber rings vulcanized on them are pressed into the track pin holes. Track shoes 7 and 8 are linked together into tracks by hexagonal pin 3, which fits tightly into the hexagonal interior spaces of the sleeves; nuts 1 and 6 hold the pin from axial displacements.

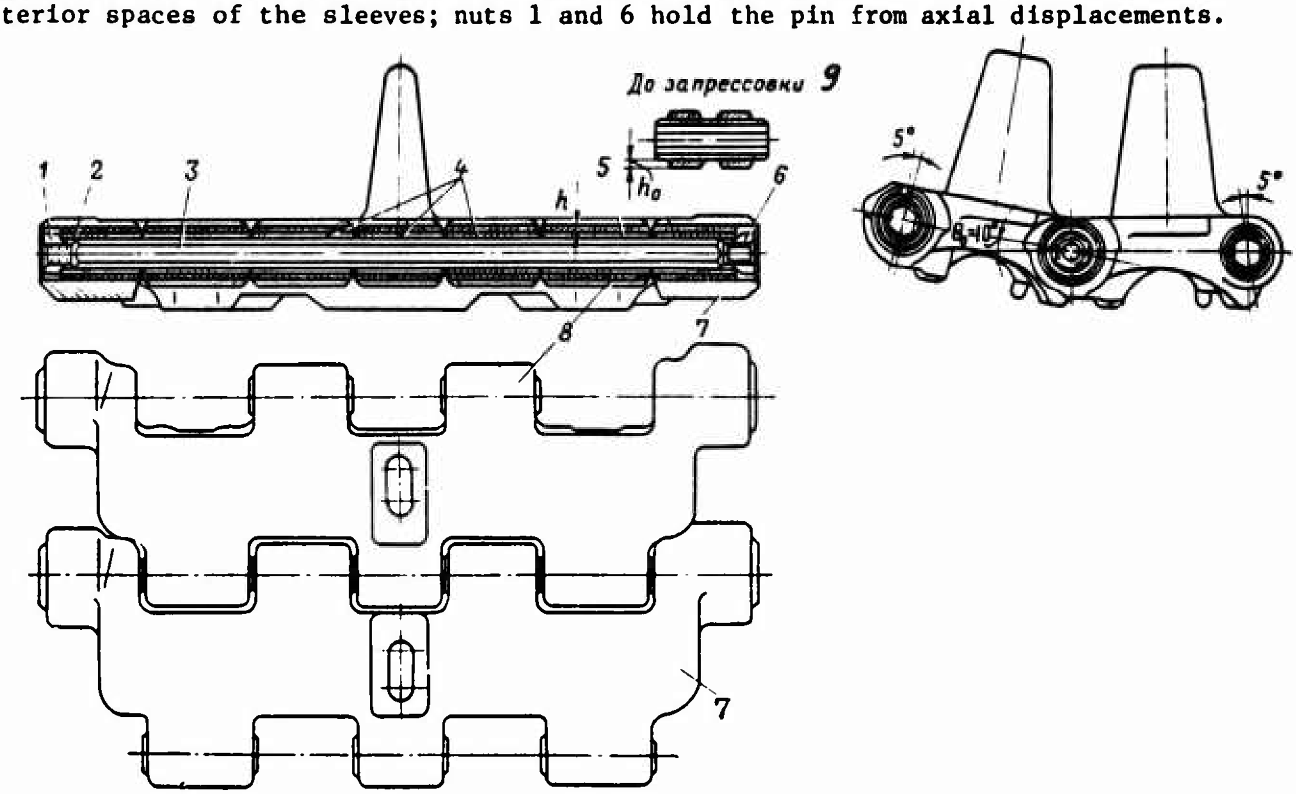


Figure 2.4.13. Track of Medium Tanks With Rubber-and-Metal Linking

Key to Figure 2.4.13 on preceding page:

1, 6.	Pin securing nuts	3.	Hexagonal pin
2, 4, 5.	Short, medium and long sleeves with rubber rings	7, 8.	Linked track shoes
		9.	Before insertion

U.S. tanks employ for tracks with rubber-and-metal links compensating devices which maintain approximately constant track tension with displacement of the extreme road wheels relative to the tank hull. The advantage of employing compensating devices is more reliable holding of the track with rubber-and-metal link on the tank even with less preliminary tension and, consequently, with greater efficiency and less intensive wear. In addition, there is a reduction in dynamic loads in the transmission and track drive, which adversely affect the operation of all its assemblies, and especially engagement of drive sprocket with track. A drawback is the greater complexity of design of tank running gear, especially with compensation for change in distance between road wheel and drive sprocket by employing a swinging final drive.

Usually the most sophisticated hydraulic track tensioners are employed on vehicles with pneumatic suspension and adjustable road clearance (Figure 2.4.14). Idler wheel crank 7 is turned to slacken or tighten track tension by means of hydraulic actuating cylinder 3, actuated by a special oil pump; the driver merely adjusts pressure and amount of oil fed into the cylinders, with the aid of a three-position valve and reduction gear. such mechanisms greatly facilitate and simplify driver actions to tighten the tracks, make this operation possible while the tank is moving, and provide a high degree of precision of adjustment and a continuous track tension monitoring capability. Drawbacks include complexity of construction, difficulty of placing actuating cylinders inside the armor hall with a tightly-sealed tank and the danger of combat damage with exterior placement, as well as a limited crank turning angle, making it necessary greatly to increase the crank radius in order to obtain large idler displacements.

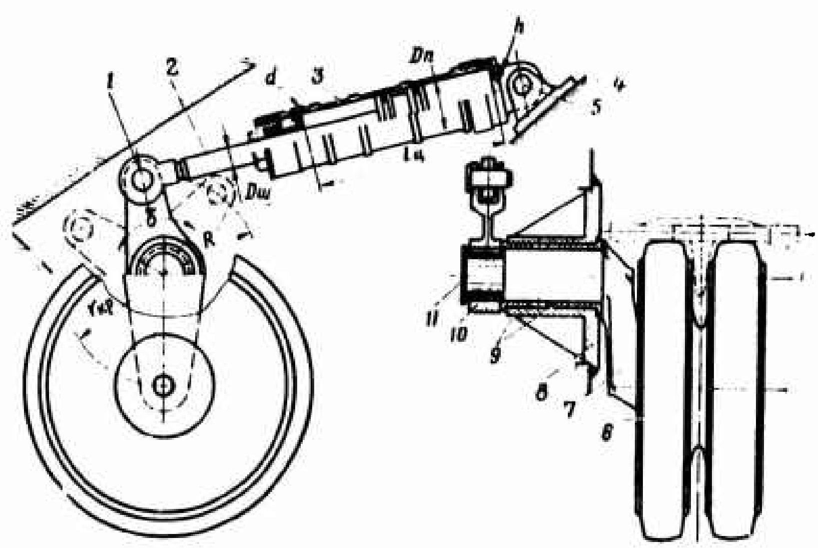


Figure 2.4.14. Hydraulic Track Tensioner

Key to Figure 2.4.14 on preceding page:

1, 5.	Pins	7.	Crank
2.	Rod with piston	8.	Bracket
3.	Cylinder	9.	Bushings
4.	Hull mounting bracket	10.	Lever
6.	Idler wheel	11.	Nut

4. Tank Equipment for Crossing Water Obstacles

Particular attention in the postwar years was devoted to problems of tanks crossing water obstacles, since the majority of theaters are characterized by an abundance of water obstacles. Under these conditions a high rate of advance is possible only if rivers are crossed quickly and without a halt. This requires that each tank, infantry combat vehicle and armored personnel carrier be capable independently of crossing a water obstacle and of immediately continuing performance of its combat mission on the far bank. Amphibious tracked vehicles are designed for crossing water obstacles, and tanks are furnished with equipment for underwater operation or individual flotation equipment.

Amphibious tanks and armored personnel carriers are lightly armored vehicles with a displacement exceeding their weight. Tanks usually perform reconnaissance missions and take part in landing assault troops, while armored personnel carriers carry personnel or military supplies. Examples of such vehicles include Soviet PT-76 tanks, BMP-1 and BMD-1 infantry combat vehicles, BTR-50P, BTR-50PK and BTR-50PU armored personnel carriers, U.S. M113 and M114 armored personnel carriers, Marine tanks, and other vehicles. Their specific features include an uncompact layout, a crew reduced to three men, hull extending over the tracks to give the vehicle transverse stability afloat, streamlined shape of underwater components, thorough sealing of interior armor-enclosed space, utilization of an ejector-type cooling system which normally operates with ducts filled with ambient water, and a second propulsion unit for swimming use.

A water jet, screw propeller or a propulsion track, the upper run of which is covered with a special hydrodynamic housing during in-water operation, are employed for propulsion afloat. This makes it possible to increase the tank propelling thrust. Water jets, first used on Soviet PT-76 tanks, are distinguished by a higher efficiency, which means greater speed at a given power-to-weight ratio and a greater swimming range. Two water jets with shutters and reverse thrust pipes ensure good tank manueverability afloat.

Equipment for operation submerged is an appurtenance of the majority of today's main battle tanks. For operation submerged, tanks should be watertight and be outfitted with uncomplicated detachable equipment, including snorkel, various seals and valves for outlet pipes, preventing water from entering the engine if it stalls while under water. After a tank emerges from the water, the snorkel is taken down, air inlet and outlet port (from inside the vehicle) are opened, and the tank is ready to proceed on its way and to fight.

Individual flotation equipment on a number of foreign tanks, in the form of extensible flotation screens or easily detachable exterior-mounted pontoons, give a tank buoyancy by increasing its displacement. Individual flotation gear in the form of

exterior-mounted pontoons consists of several parts. Screw propellers taking power off the tank's drive sprockets are mounted in the rear pontoons. After climbing onto shore, the pontoons are easily removed without the crew leaving the tank. Such flotation gear, in contrast to a collapsible screen, enables a tank to deliver fire while afloat and while moving onto the shore, but it is more cumbersome and difficult to mount. In addition, it resists small-arms fire, since the pontoons are filled with a buoyant lightweight material with a density of approximately $0.05 g/cm^3$.

Amphibious vehicles as well as tanks with underwater operation gear and flotation equipment are equipped with bilge pumps, navigation gear and crew lifesaving gear.

Chapter 5. ARMORED VEHICLE ELECTRICAL EQUIPMENT AND AUTOMATIC CONTROL GEAR

The development and improvement of armored vehicles has been characterized by a continuous rise in the level of automation of combat and operating processes.

Thanks to the extensive adoption of automatic systems, there has occurred a qualitative leap forward in improving the principal combat performance characteristics of today's tanks. Improvement of tanks, infantry combat vehicles and armored personnel carriers in turn ensures ground troops the capability successfully to accomplish all combat missions on the battlefield.

Problems of mechanization and automation are comparatively simpler and, most important, are more reliably resolved with the aid of electrical devices, and therefore improvement of various armored vehicles has been accompanied by further adoption of electrical circuitry and devices.

Today's tanks are equipped with an ever increasing quantity of electrical machines, instruments and devices. A tank contains more than 30 electrical machines, more than 100 relays and switches, approximately 200 semiconductor devices, and more than 1.5 km of wiring. The proper working order and operating reliability of electrical equipment and automatic control gear determine to a significant extent the combat efficiency of modern armored vehicles.

1. Electrical Equipment of Armored Fighting Vehicles

The electrical equipment of today's armored fighting vehicle consists of sources of electric power, appliances using electric power, monitoring and measuring equipment, wiring, and auxiliary equipment. Figure 2.5.1 contains a schematic diagram of tank electrical equipment.

Sources of electric power. A DC generator is a tank's principal source of electricity; when the tank engine is operating the generator supplies power to all power-consuming devices, as well as charging the storage batteries.

The storage batteries are an auxiliary source of electric power. The storage batteries have the job of powering appliances when the engine is not running (in particular, the electric starter). The generator and storage batteries are connected together in parallel.

The tank generator runs off the tank engine and therefore operates at variable rpm. Constant generator voltage is provided by an automatic voltage regulator.

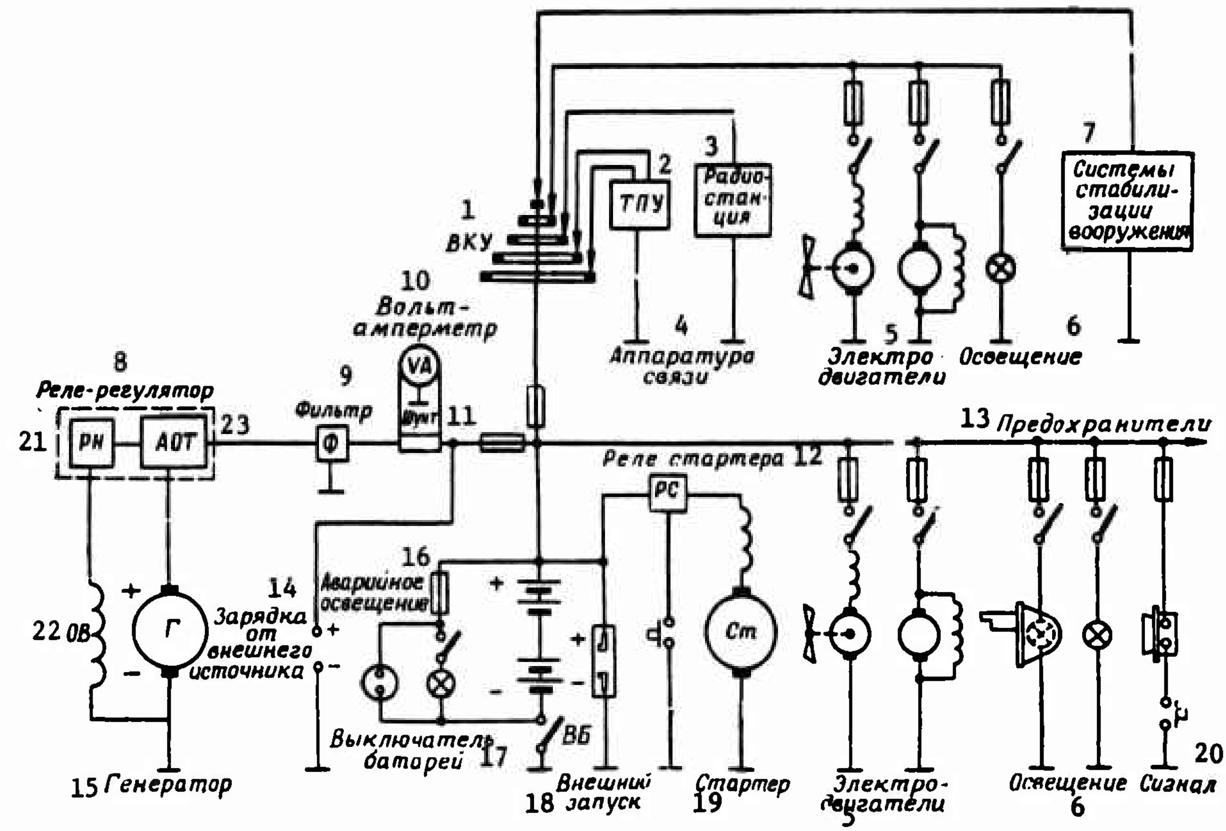


Figure 2.5.1. Schematic Diagram of Tank Electrical Equipment

Key:

1. Rotating contact arrangement
2. Tank intercom system
3. Radio set
4. Communications equipment
5. Electric motors
6. Lights
7. Weapon stabilization systems
8. Voltage regulator-relay
9. Filter
10. Volt-ammeter
11. Shunt
12. Starter relay
13. Circuit breakers
14. Charge from external power supply
15. Generator
16. Emergency lights
17. Battery switch
18. External start
19. Starter
20. Horn
21. Voltage regulator
22. Field coil
23. Automatic reverse current switch

An automatic reverse current switch is provided to disconnect the generator from the line when the engine shuts off and to connect the generator to the line when engine rpm and generator voltage reach a specified value.

The voltage regulator and automatic reverse current switch are placed in a single housing and called the voltage regulator-relay.

Other sources of electric power include current and voltage converters.

Power using devices. The biggest electric power consumer on a tank is the electric starter (10-15 kw), which is a series-excitation motor powered by storage batteries.

Tank electric power consumers include weapon stabilization systems (2.5-3.5 kw), tank protection and habitability systems (1.0-1.5 kw).

Relatively heavy users of electric power include electric motors driving pumps, fans and other auxiliary devices, gun and machinegun electric triggers, as well as the radio set and tank intercom system.

Numerous tank lights, light and sound warning devices comprise a large group of electric power consumers.

Tank lights subdivide into interior (overhead lights, flashlights, portable lamp), assisting crew operation in a tank with closed hatches, exterior (headlight, running lights), permitting a tank to operate at night, and special (dial, sight, turret race, and gun level lights). A tank also contains emergency lights which operate when the battery switch is off and which make it possible to operate inside a tank with electrical system damage and other malfunctions.

Another user of electric power in armored vehicles with a carburator engine is the battery ignition system.

Monitoring and measuring devices. These devices monitor the status and operation both of the electrical system and of other tank systems (engine fuel, lubrication and cooling, etc). Every tank usually contains the following instruments:

volt-ammeter -- a combination electrical instrument which measures voltage and current, which provides capability to evaluate the status of electric power sources and electrical system parameters, as well as to check the operation of control relay devices;

an electric tachometer to measure engine crankshaft rpm;

an electric speedometer to measure tank speed;

electric thermometers to measure water and oil temperature;

electric pressure gauges to measure oil pressure;

a Hobbs meter to measure total tank engine operating time;

a fuel gauge to measure quantity of fuel in the tanks.

All monitoring and measuring devices are electrical.

Wiring. All electrically-operated devices are connected to power sources via distribution devices (panels) and are individually or group-protected. Shielded wires with copper conductors ranging from 0.35 to 95 mm^2 in section are used in connective wiring.

As a rule wiring employs a single-conductor arrangement. The tank hull serves as the second (negative) wire.

Auxiliary equipment. Auxiliary equipment includes the following:

the rotating contact arrangement, which transfers electric power from the tank hull, where the power sources are located, to the rotating turret;

switches, buttons, etc;

adapter sockets, plug connectors, etc;

fuses and circuit breakers, which protect power sources and circuits from overloads.

In the process of evolution and improvement of tank design and tank electrical equipment, the number of electric-powered devices and their power have increased and electrical equipment has become more complex, but it basically conforms to the above classification.

Tank generators and voltage regulator-relays. The power output of DC tank generators has been constantly increasing and today has reached 10 kw. With a further increase in the power of tank generators and direct-current machines it is more difficult to build a reliable brush-commutator assembly, since commutator weight increases, making it more difficult to ensure its mechanical strength. Foreign engineers believe that the alternator is the tank generator of the future, since the reliability of an alternator is twice that of a DC generator, and its power output is 50 percent greater for a given size.

Method of voltage regulation exerts considerable influence on the size and characteristics of generators.

At the present time carbon, vibrator and transistor regulators are employed, which stabilize a specified voltage level with change in generator armature rpm.

Carbon-pile voltage regulators, which utilize the property of a carbon pile to change its resistance under compression, possess highly unstable characteristics. Because of this, they have been used very little in tank electrical equipment.

A vibration-type voltage regulator is employed for generators of less than 5 kw, since its operating reliability is limited by maximum excitation current interrupted by the contacts.

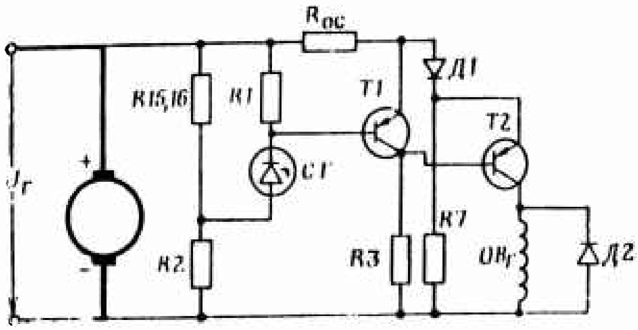


Figure 2.5.2. Schematic Diagram of a Tank Generator Contactless Voltage Regulator

Primarily contactless voltage regulators are employed for voltage regulation on modern tank generators. The operation of contactless voltage regulators utilizes the properties of semiconductor devices -- transistors (semiconductor triodes) and semiconductor diodes.

Transisterized voltage regulators (Figure 2.5.2) are versatile and most promising from the standpoint of their employment in armored vehicle electrical equipment.

Tank storage batteries. A characteristic feature of modern storage batteries used on tanks is their large capacity and low internal resistance. This provides reliable tank engine starting both in summer and winter. Employment of powder metallurgy techniques for the positive and negative plates and utilization of separators made of microporous rubber and plastic ensure reliable storage battery performance and have greatly decreased the probability of plate sulfating. Storage battery service life has increased greatly. Allowable storage battery shelf time in a dry charged state has also increased. When necessary, such a battery can be installed in a tank after brief preparation lasting only two or three hours.

Alongside the positive features of lead-acid storage batteries, we must note one major operational drawback: as battery temperature drops, in-vehicle charging conditions sharply deteriorate. It is correspondingly more difficult to start an engine with the electric starter.

Worsening of battery charging characteristics in cold weather is due to an increase in battery internal resistance and decreased rate of diffusion of fresh electrolyte within the plates. In order to increase the efficiency of storage batteries in cold weather, they are sometimes insulated and even heated.

2. Weapon Stabilization System

In modern warfare one of the principal modes of delivering tank fire is fire while the tank is moving. Accuracy and rate of fire drop off sharply, however, when firing while the tank is in motion, as a consequence of tank hull oscillations, causing an increase in shell dispersion and worsened crew operating conditions when delivering fire.

Tank hull oscillations are of a random character, and their amplitude and frequency are fairly large; therefore it is impossible manually to maintain the gun in the desired direction and to hold the aiming mark on the target even with modern aiming drives.

Shell dispersion is also strongly affected by firing interval -- the time from the moment aiming is completed and the decision is made to fire, to the moment the projectile leaves the bore. During this time interval aiming is not being performed, while hull, turret and gun oscillations are continuing. Therefore the direction in which the bore axis is pointing at the moment the projectile emerges will be different from the direction set by the gunner.

In order to increase effectiveness of fire while a tank is in movement, an automatic device is needed, which would continuously generate a stabilizing moment equal in magnitude but opposite in sign to the disturbing moment. In such a case, the gun and turret would maintain constant their attitude in space. These functions

are performed by a tank weapon stabilizer -- an automatic control system which ensures smooth gun laying and keeping the bore axis pointed in the desired direction during the hull oscillations of a moving tank.

The operating principle of a tank gun stabilization system (Figure 2.5.3) is as follows. During tank movement on uneven terrain, a disturbing moment acts on the gun as a consequence of hull oscillations; the magnitude and direction of this moment are continuously changing, as is the controlled quantity -- gun elevation angle $\varphi_б$. If the gun, turning in its trunnions, is linked to the tank turret by a slave mechanism (electrohydraulic or electrical), then by controlling the operation of this mechanism one can generate a moment which compensates for the disturbing moment, and thus stabilize the gun.

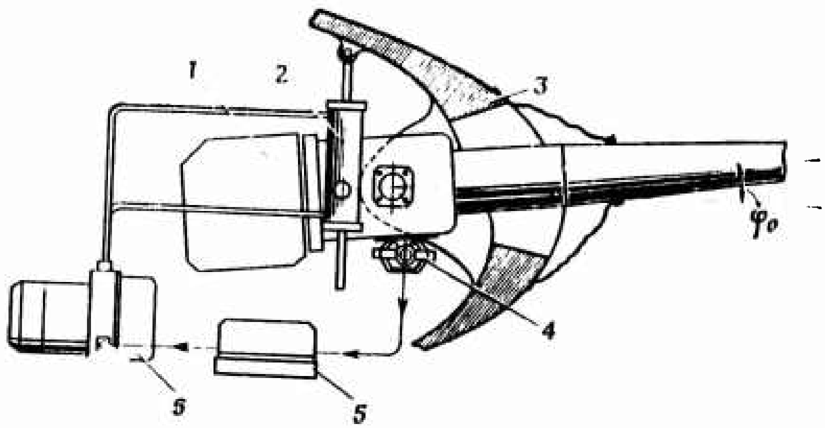


Figure 2.5.3. Tank Gun Stabilizer

Key:

1. Gun
2. Stabilizer cylinder
3. Tank turret
4. Free gyroscope
5. Electronic amplifier
6. Hydraulic actuator

The stabilizer control signal can be formed either by direct measurement of the disturbing moment or indirectly -- by determining the gun's angle of deviation from the desired direction. It is technically difficult directly to measure the disturbing moment, while measurement of angle of deviation does not involve major difficulties and is extensively employed in modern stabilizers.

A special direction setting mechanism provides stabilization of the desired direction with a fairly high degree of accuracy. A free gyroscope can serve as such a setting mechanism, the stabilization and precession properties of which are utilized in tank weapon stabilizers.

The gyroscope base is secured to the gun in such a manner that the axis of its outer frame is parallel to the axis of the trunnions. When gun oscillations occur between the plane of the outer frame and the bore axis, displacement angle θ is formed, equal to the difference between the desired elevation angle $\varphi_з$ and actual elevation angle $\varphi_б$.

Sensors (potentiometric, rotating transformers, or selsyns) generate an electrical signal proportional to the angle of displacement.

The greater the angle of displacement, the greater will be transducer output voltage U_y, while the direction of gun deviation determines the polarity phase of the output signal. This signal is too weak directly to control the actuating drive. The control signal is amplified and rectified with the aid of electronic (semiconductor, magnetic, relay, and other) amplifiers.

The actuating cylinder generates stabilizing moment M_{CT}, directed against disturbing moment $M_{вн}$. Sum of moments, $M_0 = M_{вн} - M_{CT}$ acting on the gun decreases, which decreases displacement angles. As a result of this, the selected gun direction remains constant (with a certain degree of accuracy).

Obviously such a system cannot keep the gun position absolutely motionless, since a displacement angle, caused by gun deviation from the desired direction, is needed to actuate the cylinder. But gun oscillations can be reduced to a magnitude which does not hinder aiming and which permits delivery of effective fire. The more sensitive the sensor, the more accurate and fast-responding the system, the smaller will be the amount of gun deviation.

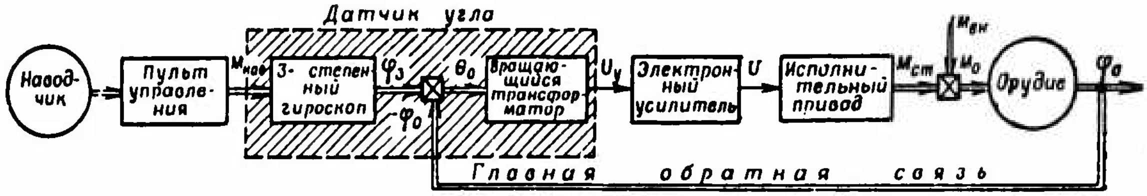
Figure 2.5.4a contains a block diagram of a gun stabilizer employing the principle of deviation-actuating adjustment.

As the gunner lays the gun on the target, working control panel PU, he causes the outer frame of the attitude sensor gyroscope to turn. The resulting displacement angle between the frame and gyroscope base secured to the gun is converted by a rotary transformer into an electrical signal. Responding to this signal, amplified by an electronic amplifier, the stabilizer actuator turns the gun at a specified rate equal to the rate of turn of the gyroscope outer frame. The greater the control panel angle of rotation, the greater the current in the windings of the attitude sensor control electromagnet, the rate of rotation of the gyroscope outer frame and, in the final analysis, the gun rate of rotation.

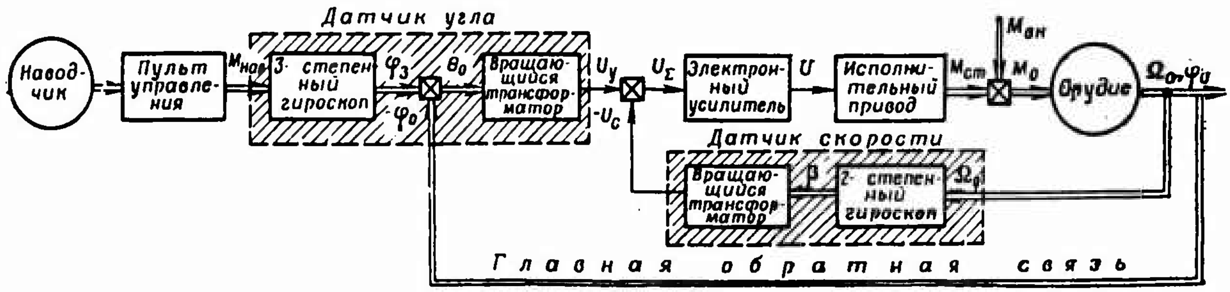
When the control is returned to the initial (neutral) position, the circuit applying current to the control electromagnet windings is interrupted, the moment developed by the electromagnet becomes zero, and the gyroscope outer frame stops turning. Gun rotation also stops.

A gun stabilizer employing this arrangement (Figure 2.5.4a), however, contains a serious drawback, consisting in poor accuracy of stabilization -- during tank movement gun and aiming mark oscillations are considerable. When stabilizer gain ("sensitivity") is increased in order to reduce these deviations, the stabilizer becomes incapable of operating, due to the occurrence of high-amplitude undamped gun oscillations. The quality of the simplest gun stabilizer can be improved by changing the waveform of the control signal generated by the attitude sensor.

The control signal waveform can be changed by feeding into the stabilizer control circuit an additional signal, proportional to the gun's absolute rate of angular motion. This signal must be summed with the attitude sensor signal, and then one can obtain a control signal of the requisite form and magnitude. The gun will deviate from the preset direction by a significantly less amount, and will brake



a



б

Figure 2.5.4. Block Diagram of Tank Gun Stabilization

a -- gun stabilization system with attitude sensor; b -- gun stabilization system with attitude sensor and rate sensor

Key:

1. Gunner
2. Control panel
3. Attitude sensor
4. Free gyroscope
5. Rotary transformer
6. Electronic amplifier
7. Gun drive
8. Gun
9. Main feedback
10. Rate sensor
11 One-axis gyroscope

---

upon approaching the preset direction; after making two or three small-amplitude oscillations, the gun will rapidly assume the preset direction.

An additional signal, proportional to the angular velocity of gun deflection, is applied with the aid of a gyroscopic rate sensor (gyrotachometer), based on a one-axis gyroscope. Figure 2.5.4b contains a complete block diagram of a gun stabilizer with a rate sensor.

Stabilizer performance is judged on the basis of accuracy of gun stabilization -- mean angular deviation from the preset direction. Number of target hits increases with improvement in stabilization accuracy. Consequently accuracy of stabilization is a most important indicator for evaluating not only stabilizers but also a tank's overall combat performance characteristics.

Special interlockings are incorporated in stabilizer control circuits in order to ensure crew safety and prevent stabilizer breakdown. As an illustration we shall examine an interlocking which eliminates gun throw after firing and provides gun stop during the recoil-counterrecoil-loading period.

On firing, the rearward-recoiling parts of the gun generate an unbalanced moment, the magnitude of which greatly exceeds that developed by the stabilizer. This moment can force the gun to turn in its trunnions in the direction of increasing elevation angle to maximum, as a consequence of which the gunner, immediately after firing, will lose the target from his field of view and will be unable to assess the result of the shot. This phenomenon is prevented by locking the gun during firing in a direction close to preselected, which facilitates laying on the target, observing the target and firing results.

But locking the gun and, with it, the sight field for an extended time prevents the gunner from observing firing results. In order to correct this problem, modern tank gun sights are equipped with independent field of view stabilizers, which operate only during interlocking.

Interlockings in modern stabilizers guarantee crew safety.

3. Ground Navigation Systems

The majority of tanks in foreign armies are equipped with navigation gear (systems). Navigation systems are one of the most important modern means of automatic troop control. In controlling troops in battle, on the march and in reconnaissance, orientation is usually secured with the aid of military topographic maps -- by comparing local features and topography with their representation on a map. This method of orientation can be successfully employed under conditions of good visibility and when adequate time is available. During hours of darkness or in poor visibility, as well as when fighting in forest, mountains or on steppe terrain, orientation is extremely difficult, and in many cases impossible. Therefore navigation systems are absolutely essential, especially for reconnaissance vehicles and command tanks.

Ground navigation systems make it possible to obtain navigation information during combat, that is, to ensure:

determination of the location of troop dispositions;

that columns and individual vehicles are following the predetermined route to the destination area (point);

actions of reconnaissance units and determination of the coordinates of reconnoitered installations;

laying out of routes of troop movement and their plotting on a topographical map.

To accomplish these tasks, navigation devices should continuously determine the coordinates and course of vehicles in movement, bearing to the destination point and distance remaining to it, as well as the coordinates of reconnoitered targets.

Navigation systems include navigat'on computers, gyroscopic course indicators (course systems), directional gyros, rangefinders, and a number of other devices.

Three navigation problems can be solved by ground navigation systems:

the first (principal) problem -- determination of coordinates X, Y of the location of a mobile object and its grid azimuth angle α ;

second problem -- determination of bearing to a predetermined destination point $\alpha_{пн}$ and distance $S_{пн}$ to that point;

third (supplementary) -- determination of the coordinates of reconnoitered targets.

To solve the first navigation problem, that is, for continuous determination of the topographical grid coordinates of a moving vehicle, its parameters of movement are employed: speed and grid azimuth. Let us assume that a vehicle is traveling across a horizontal stretch of terrain from point 0 to points 1, 2, etc, as shown in Figure 2.5.5. The increments of coordinates on these segments will be as follows:

$$\left.\begin{aligned}\Delta X_1 &= V_1 \Delta t_1 \cos\alpha_1 = \Delta S_1 \cos\alpha_1;\\ \Delta Y_1 &= V_1 \Delta t_1 \sin\alpha_1 = \Delta S_1 \sin\alpha_1;\end{aligned}\right\} \quad (2.5.1)$$

$$\left.\begin{aligned}\sum_{i=1}^{n} \Delta X_i &= \sum_{i=1}^{n} V_i \Delta t_i \cos\alpha_i = \sum_{i=1}^{n} \Delta S_i \cos\alpha_i;\\ \sum_{i=1}^{n} \Delta Y_i &= \sum_{i=1}^{n} V_i \Delta t_i \sin\alpha_i = \sum_{i=1}^{n} \Delta S_i \sin\alpha_i.\end{aligned}\right\} \quad (2.5.2)$$

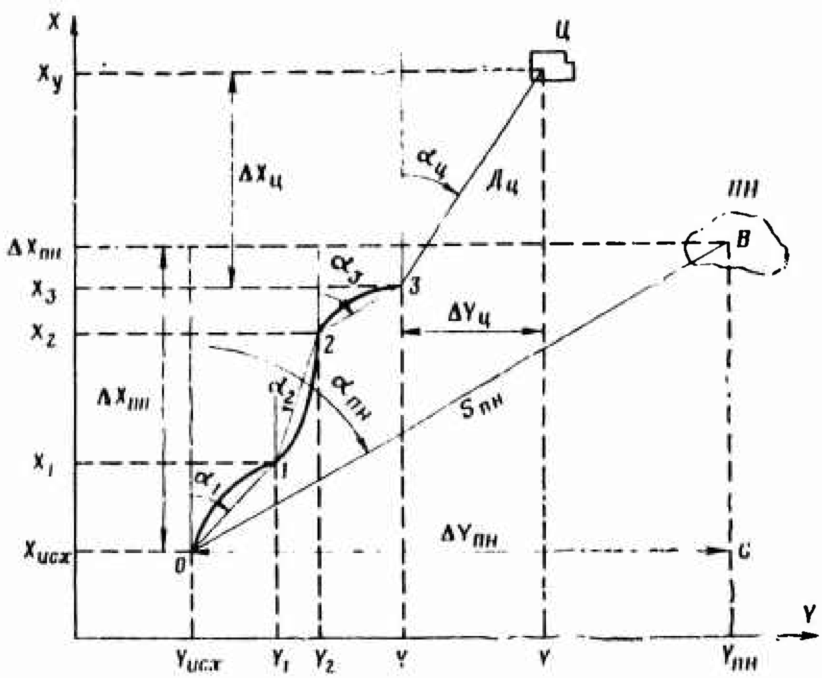


Figure 2.5.5. Solving Navigation Problems

Current vehicle coordinates X and Y for any moment in time can be obtained by algebraic adding of initial coordinates $X_{исх}$ and $Y_{исх}$ with increments $\sum_{i=1}^{n} \Delta X_i$ and $\sum_{i=1}^{n} \Delta Y_i$:

$$X = X_{исх} + \sum_{i=1}^{n} \Delta X_i = X_{исх} + \sum_{i=1}^{n} \Delta S_i \cos \alpha_i; \qquad (2.5.3)$$

$$Y = Y_{исх} + \sum_{i=1}^{n} \Delta Y_i = Y_{исх} + \sum_{i=1}^{n} \Delta S_i \sin \alpha_i. \qquad (2.5.4)$$

Figure 2.5.6. contains a block diagram of ground navigation equipment.

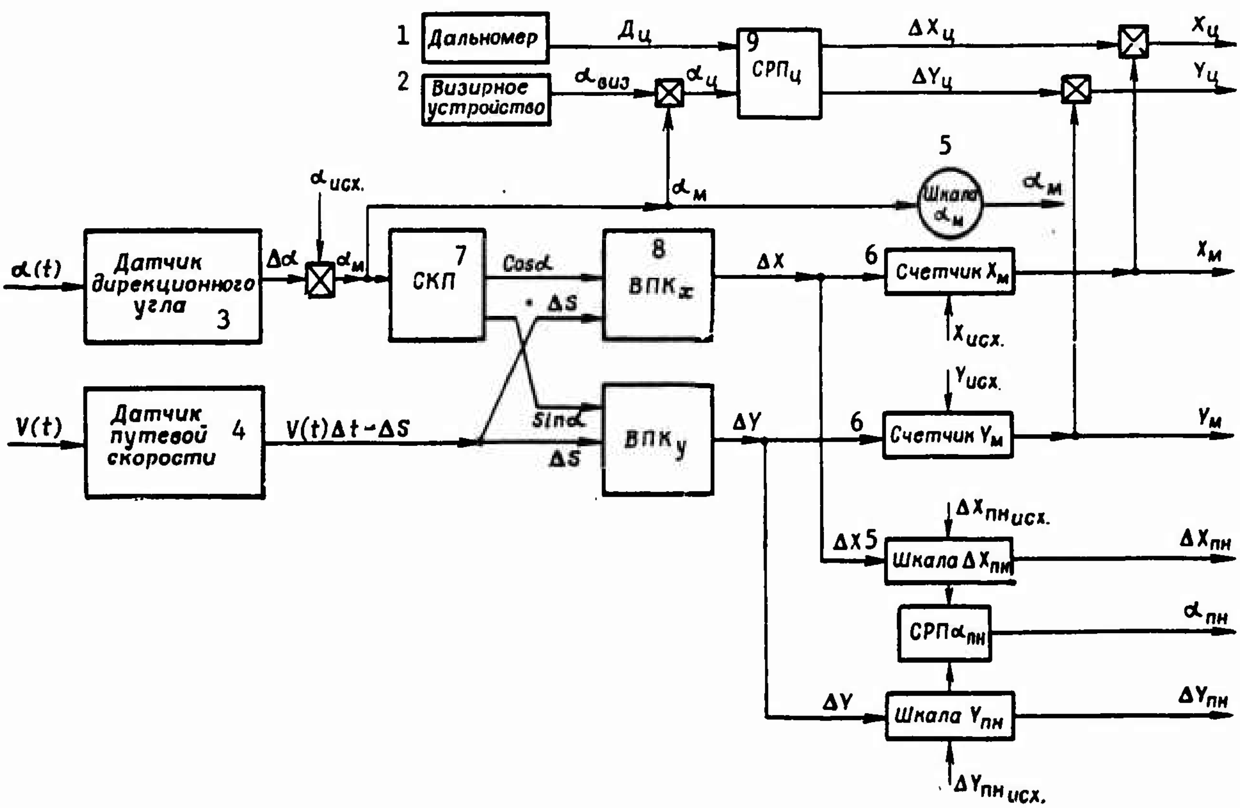


Figure 2.5.6. Block Diagram of Ground Navigation Equipment

Key:
1. Rangefinder
2. Sighting device
3. Grid azimuth sensor
4. Ground speed sensor
5. Scale
6. Indicator
7. Sine-cosine converter
8. Coordinate increment computer
9. Computation device

As the vehicle moves, a ground speed sensor determines vehicle speed V_M and proportional ground covered increment ΔS, while the grid azimuth sensor determines change in vehicle grid azimuth angle α_M. Vehicle grid azimuth angle α_M is recorded by a scale device and is fed into a sine-cosine converter, which computes the sine and cosine of the vehicle grid azimuth angle $\sin\alpha$ and $\cos\alpha$.

Ground covered increment ΔS and trigonometric functions $\sin\alpha$ and $\cos\alpha$ respectively are fed into coordinate increment computers $BK\Pi_x$ and $BK\Pi_y$, which compute ΔX and ΔY.

Coordinate increaments ΔX and ΔY are added with initial coordinates X_{Hcx} and Y_{Hcx}, are recorded by corresponding coordinate indicators or are traced out on a map.

The second navigation problem is solved in those cases where the coordinates of the destination point (area) are known. If the vehicle carries navigation equipment which can solve the principal navigation problem, it is possible to determine bearing to the destination point and to compute distance remaining to it $S_{\pi H}$. The principle of solving the second navigation problem is shown in Figure 2.5.5. From right triangle OBC one determines distance to destination $S_{\pi H}$ and direction $\alpha_{\pi H}$ of movement to that point:

$$S_{пн} = \sqrt{\Delta X_{пн}^2 + \Delta Y_{пн}^2} = \sqrt{(X_{пн} - X)^2 + (Y_{пн} - Y)^2}; \qquad (2.5.5)$$

$$\alpha_{пн} = \operatorname{arctg} \frac{\Delta Y_{пн}}{\Delta X_{пн}} = \operatorname{arctg} \frac{Y_{пн} - Y}{X_{пн} - X}. \qquad (2.5.6)$$

Thus input data for solving this problem are vehicle current coordinates X and Y and destination coordinates $X_{\pi H}$ and $Y_{\pi H}$. In order to proceed to the destination point by the shortest route, the driver should advance his vehicle with the least difference between angles α and $\alpha_{\pi H}$, with continuous decrease in distance $S_{\pi H}$. Upon arrival at the destination point, $S_{\pi H}$ will be zero.

The third navigation problem is solved by navigation equipment with utilization of a rangefinder and sighting device on the vehicle.

Figure 2.5.5 shows solving of this problem. With the aid of a sighting device one determines the angle of view to the target $\alpha_{\text{вн}}$. This angle is added with the vehicle grid azimuth angle, and the target grid azimuth angle $\alpha_ц$ is computed. Range to target $Д_ц$ is determined with the rangefinder.

Computing devices determine coordinate increments from vehicle to target $\Delta X_ц$ and $\Delta Y_ц$. These increments are added with vehicle coordinates, and target coordinates $X_ц$ and $Y_ц$ are determined:

$$X_ц = X_т + \Delta X_ц = X_т + Д_ц \cos\alpha_ц; \qquad (2.5.7)$$

$$Y_ц = Y_т + \Delta Y_ц = Y_т + Д_ц \sin\alpha_ц. \qquad (2.5.8)$$

The necessity of employing ground navigation equipment on tanks and other armored vehicles has been confirmed by a number of exercises held in recent years.

Chapter 6. COMMUNICATIONS GEAR AND INFRARED EQUIPMENT

1. Communications Gear

Successful accomplishment of a combat mission by the tank and tank (motorized rifle) unit depends in large measure on control, a principal means of which is communications. The tank commander receives fire control and maneuver commands from his unit commander by radio, utilizing external communications. Communications between tank commander and crew members and between crew members (intercommunication) employ a tank intercom system.

External communications should provide a commander with control over subordinate units (vehicles), communications with the next higher commander, as well as cooperation with neighboring units and units of other arms. It is difficult to perform these tasks with a single radio set. Therefore a tank carries one or several radios of a single type or of different types.

Very tough demands are imposed on a tank radio, proceeding from the character of modern warfare and the conditions of operation of communications gear in a tank. Under conditions of continuous conduct of battle, a tank radio set should provide communications to a maximum range during operation standing and moving, day or night, year-round. It is not advisable for a radio set to operate at ranges exceeding the maximum possible distances between unit commanders and tanks in battle, since this would eliminate the possibility of using the same communications frequencies in other units or would increase the possibility of interference from radios of other units operating on the same frequencies.

Since tank units work in cooperation with one another in the course of combat and with units of other arms, they require radios with a common frequency band and a sufficient number of operating frequencies for the radio nets of all units. In addition, one must take account of the enemy's efforts to disrupt troop communications and control by jamming. In order to maintain reliable communications under conditions of hostile jamming, the need arises to retune radios to reserve frequencies, which increases to an even greater degree the number of required radio frequencies. Radios must also switch to other frequencies in other instances, such as to establish contact with units of other arms, as well as when a tank is damaged, when the tank commander must communicate with maintenance and recovery units. In order that this frequency shift be accomplished rapidly and simply, a radio set should provide for preliminary tuning to several communications frequencies.

Tank internal communication enables the commander to control his crew and permits communication among crew members. It is accomplished with the aid of the tank intercom system, which should have capability of switching over when necessary (by one or several crew members) from intercom to external communications with the tank radio.

The tank commander performs his job under difficult conditions. He must maintain constant radio contact with his unit commander, maintain battlefield surveillance, and control his crew. Therefore tank radio gear should be simple and reliable in operation, have a minimum number of controls, and not overly fatigue radio operators. Crew members become fatigued when operating a radio due to constantly hearing receiver noise in their headsets, requiring listening closer to hear their call. In order to avoid this, the interphone headset should be automatically disconnected from the radio transceiver as soon as communication is completed, connecting into the intercom system, with external communications switched in again when a call comes. In addition, receiver noise should be suppressed during communication.

Since the hands of the tank commander and other crew members are frequently occupied, there is a need for switching the radio from receive to transmit by voice.

The interior space of the fighting compartment and tank driving compartment is extremely limited. Therefore greater demands are imposed on the physical size of tank radio gear. It should be as small as possible, and its location should not hinder the crew from successfully performing their duties.

Since tank radios and intercom systems provide control in combat, and it is very difficult to correct malfunctions on the spot, rigid operational reliability and simplicity requirements are imposed on communications equipment. Radio equipment design, handling and care procedures should be such that there is practically no possibility of equipment failure.

Modern tank radios in a number of armies operate in the VHF band, in which with frequency modulation, quality and effective range of communications are practically independent of time of day or year, permitting maximum distances between unit commanders and tanks during performance of missions.

In the U.S. Army, for example, the AN/VRC-12 tank radio operates in the 30-75.95MHz band and provides communications up to a range of 25 km while moving and up to 35 km standing.

In the army of the FRG, the Leopard tank carries a Fugt/sem-25 radio, which operates in the 20-69 MHz band and provides communications to a range of up to 40 km.

In the VHF band radios have a sufficient number of operating frequencies (the AN/VRC-12 has 920, and the Fugt/sem-25 has 880) for all tank units. High radio set frequency stability permits stable radio communications at predetermined fixed frequencies not only when standing but also during tank movement. Tuning the radio in advance to several frequencies (the AN/VRC-12 -- to 10 frequencies) helps in cases of necessity to switch rapidly from one frequency to another and to switch the set from one radio net to another without additional tuning operations.

Tank radios can be switched from receive to transmit by voice in duplex mode, and receiver noise can be eliminated by switching on the squelch circuit. At the same time, when operating in duplex mode, the radio operator must pay close attention, for every word he speaks will automatically switch on the transmitter and go out onto the air. This can lead to disruption of communications between other stations in the radio net. Therefore it is advisable to employ this mode when the tank commander's hands are occupied. At all other times simplex mode should be used, with the radio switched from receive to transmit and vice versa with a chest switch. In this mode an audio-frequency call to another station is sent out by pressing a special button. At the other station the tank (unit) commander hears this signal on his receiver.

Sometimes, due to situation conditions, receive-only instructions are given. This is essential prior to initiation of combat in order to make it more difficult for enemy signals intelligence to determine the location of units. During this time radios should be on continuous listening watch, so that in case of a surprise enemy attack the senior commander can immediately assign a mission to his subordinate and control him in combat. For this purpose a tank radio has a third operating mode -- "Listening Watch," whereby power requirements are reduced as a consequence of the fact that the filament circuits of those tubes not operating for receiving do not receive current. If it is necessary to transmit, the mode selector switch must be switched from "Listening Watch" to "Simplex" and the transmitter tubes warmed up for 1 minute.

Switching on the receiver's noise suppressor makes it less fatiguing for a tanker operating the radio, but at the same time cuts range of communications by approximately one third to one half. This must be considered during long-distance communication.

All radio controls are located on the transceiver front panel. The radio is tuned sequentially to several preselected frequencies. After the radio has been tuned to the required number of frequencies, however, it can be switched quickly and easily from one frequency to another -- merely by turning the fixed frequency setting knob.

In order to reduce mutual interference by stations located at a single control facility close to one another (up to 100 meters) but operating in different radio nets, they are assigned operating frequencies with considerable separation. Radio communications in different radio nets on adjoining frequencies without mutual interference are possible if the stations are at least 1 kilometer apart.

Brief (with signals) and precision transmission work makes it difficult for hostile signals intelligence to locate an operating station and ensures more reliable communications. Therefore in simplex mode, following radio signal transmission, one must immediately switch the radio to receive, for otherwise the carrier frequency of the operating transmitter will impede communications between other stations in the net; in duplex mode transmission, words must be spoken smoothly, without long (not more than half a second) pauses, during which automatic transmitter switch-off is possible.

A tank intercom system consists of intercom sets, chest switches, headsets, and plug connectors. Set 1 provides the tank commander with internal communications with any other crew member and is used for his radio communications. Set 2,

connected to set 1, provides the gunner the same capabilities. The other sets provide capability of intercommunication among crew members. If an armored vehicle contains two radios, set 1 is placed by the loader, and set 2 -- by the commander.

In the switching part of set 1 there is a special relay by means of which, when any chest switch is put in the call position, the headsets and throat microphones of the tank commander or driver connected to the radio at this time, switch over to intercom.

When a vehicle is equipped with a tank intercom system, the operators of sets 1 and 2 control the radio set by switching the chest switch to the ПРД position to transmit and by releasing it to the middle position ПРМ -- to switch over to receive.

Armored vehicle radio equipment should be fully combat ready at all times.

Rapid advances in radio electronics make it possible to build today highly reliable, small and economical radio equipment. New principles of designing electronic devices call for changing over from numerous discrete active and passive components to microminiature single units performing the same functions as conventional radio electronic units.

Radio electronic circuitry involving such solid-state units are called solid-state circuitry. In conventional circuits a large part of the volume and weight is made up of structural elements which do not take part in the electrical process (panels, insulating components and fasteners, exterior hardware, radio part housings, system of terminals, etc). Therefore the volume and weight of active materials directly participating in electrical processes comprise only a fraction of the percent of the total weight and volume of the hardware. In addition, in conventional circuitry placement density does not exceed two or three components per cubic centimeter. In solid-state circuitry there is a substantial increase in the percentage share of active materials, which sharply reduces the volume and weight of radio equipment. The need for heat dissipation, circuit layout and other difficulties make it impossible to obtain great savings in full measure, but for all practical purposes there has already been achieved a 200-300-fold decrease in physical size of solid-state circuitry in comparison with conventional.

The main virtue of solid-state circuitry is its high degree of operational reliability, due to an approximately 75 percent reduction in the number of soldered connections within a circuitry unit as a result of employment of a single-crystal unit and sealing of active and passive circuit elements, which greatly reduces the effect of humidity and moisture on them. The cost of solid-state devices, however, is still greater than conventional circuitry. Future prospects for size reduction are good.

Consequently, employment of solid-state circuitry in radio equipment will make it possible sharply to increase equipment operational reliability, to reduce size and substantially simplify servicing.

2. Infrared Equipment

The element of surprise and concealment of tank operations during the hours of darkness can be achieved to a substantial degree by active and passive night vision devices, as well as thermal radiation imaging equipment employed on some armored vehicles. This equipment enables one to observe enemy activities and terrain at night, to deliver aimed fire from the tank gun and machinegun, and to operate vehicles on the march and in combat.

Active or illumination-type night vision devices (Figure 2.6.1) are based on utilization of infrared rays, which are invisible to the human eye. This equipment consists of three principal devices: observation (aiming) device 2, power supply 5, and infrared searchlight 6. The latter differs from conventional light sources: a special light filter blocks visible light and passes only infrared radiation, which is directed toward the target A-B and the terrain. A portion of the infrared rays reflected by these objects strike the instrument, objective lens 1 of which places an invisible image of the target A'-B' and the terrain on the photocathode of image converter tube 3. The image converter tube in turn produces on a screen visible image A"-B", viewed by the observer through eyepiece 4. A continuous high voltage of 10,000-20,000 volts is applied from power supply 5 to the image converter tube.

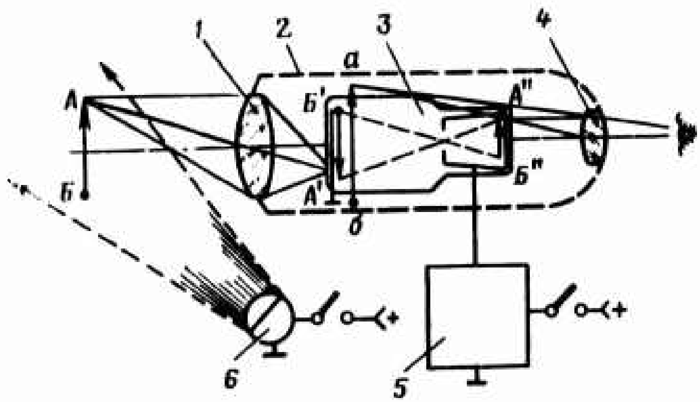


Figure 2.6.1. Diagram of Active-Type Night Vision Device

Key:

1. Objective lens
2. Observation instrument
3. Image converter tube
4. Eyepiece
5. Power supply
6. Infrared searchlight

Depending on function and location, night vision devices are monocular and binocular, telescopic and periscopic. They are in a fixed mount, or rotate horizontally, or rock in the vertical plane. Some models are hinged to the driver's helmet.

The power supply can be either a separate unit or built into the vision device. Infrared searchlights are mounted separately or together with conventional searchlights. The design of some searchlights provides for illuminating the terrain with infrared or visible light. The crew selects type of illumination on the basis of probability of enemy detection of infrared radiation, range to target, and other factors. Some searchlights provide the capability of varying beam convergence

without a crew member leaving the vehicle, providing a broad or narrow field of observation. A brief increase in searchlight radiation power is sometimes employed for identifying targets at great distances.

The effective range of active-type devices depends greatly on intensity of illumination sources. Therefore, it is noted in foreign publications, searchlights of considerable size and weight are required for observation of distant targets. This complicates placement of equipment on tanks and decreases its survivability. In addition, operation of infrared searchlights cannot be concealed from the adversary if he is conducting surveillance with night vision devices.

In spite of the drawbacks mentioned above, illumination-type devices are extensively employed in foreign tank troops. They offer greater concealment of combat vehicles movement at night from the large numbers of enemy optical reconnaissance gear, and they offer surprise aimed fire from the tank gun. In addition, special methods of illuminating terrain and targets are employed. In battle the projector on some tanks emits a rapidly-winking beam, on others the searchlight winks at appreciable intervals, while the rest of the tanks in the unit deliver fire. This hinders the adversary from determining the location of tanks with operating night vision devices. When moving in columns, searchlights are switched on only on the lead vehicle, one or two intermediate vehicles, and the trail vehicle. All others utilize the illumination provided by these vehicles.

Passive or illuminationless night vision devices, which operate on the weak natural night lighting, that is, on scattered visible light from the stars and moon, are considered more promising. The exceptional sensitivity of this equipment is achieved by obtaining fast optics and image converter tubes with a very high image intensification.

Passive night vision devices on foreign tanks have gone through two development stages. First-generation instruments employ converters containing several sequentially positioned simple converters (stages), similar in design to those in active equipment.

When high voltage is applied to each of the stages, total intensification of the image produced by the objective lens on the input photocathode reaches a gain of 50,000 in a three-stage converter. As a result, a tank can be observed at a distance of up to 1,200 meters in moonlight. Effective range is substantially reduced with weaker starlight.

Night vision devices with multistage converters, however, are large in size and, foreign military experts claim, are poorly protected against light interference. In connection with this, second-generation instruments were developed, which employ single-stage image converters with a microchannel image intensifier.

Such a converter (Figure 2.6.2) contains glass plate 4, approximately 0.5 mm thick, in front of fluorescent screen 5. This plate is perforated by a great many cylindrical channels 6 approximately 10 microns in diameter, the interior walls of which are coated with a semiconductor layer. Thin metal electrodes 7 are mounted on the faces of the plate. Electrons, driven from photocathode 2 by the action of received light, are accelerated by the several thousand volt difference in potentials, proceed toward the screen, and strike plate 4. Photoelectrons 9, upon

entering one of the microchannels, collide with the channel wall and knock off secondary electrons 10, which are accelerated along the channel axis by the additional electric field formed between electrodes 7. The secondary electrons successively strike the wall, and their number increases. Therefore an electron flow amplified almost 10,000 times speeds from the plate to the screen.

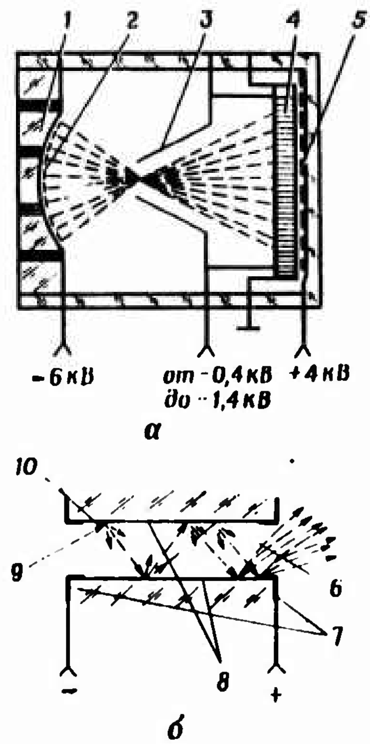


Figure 2.6.2. Diagram of Image Converter Tube

Key:

a. With microchannel image intensifier
b. Diagram of electron multiplication within a channel
1. Inlet window of fiberglass
2. Photocathode
3. Focusing electrode
4. Microchannel plate
5. Fluorescent screen
6. Microchannel
7. Metal electrode
8. Semiconductor layer with high secondary-emission rate
9. Photoelectron
10. Secondary electrons

According to foreign sources, a converter with a microchannel plate has greater total intensification than a three-stage unit, is one tenth the size, and costs less. In addition, each microchannel acts as an independent electron multiplier and can become saturated without affecting adjacent channels. This eliminates hindrances to observation caused by intensive light sources striking the instrument's field.

According to information published abroad, passive thermal radiation vision devices have a great potential for the future.

These devices detect the thermal radiation of target and background with a multiple-element infrared radiation detector. A thermal picture of the terrain and objects on it is created by the objective on a mosaic of cooled point detectors. An electrical signal is taken sequentially from each point detector, which is proportional to the radiation striking it. These signals are amplified and applied to a cathode ray tube. A visible image of the outlines of both features and targets is formed on the tube screen.

It is claimed abroad that personnel and equipment can be spotted under conditions of light fog, in smoke and haze, and even through foliage, and therefore tank thermal radiation vision devices can be used not only at night but also to detect camouflaged targets during daylight hours or to observe shellbursts at twilight. This equipment's high resistance to jamming is also noted.

Mobile ground target reconnaissance radars are used to some extent in addition to the equipment described above, both at night and during daylight hours. But radars, it is noted in the foreign press, do not provide a view or identification of these objects. Only target detection is possible on the basis of scope returns, as well as determination of range and a rough determination of bearing. Operation of radar gear, however, is difficult to conceal.

3. Laser Equipment

In recent years various devices based on employment of lasers have been developed abroad to increase tank combat capabilities.

As we know, a laser is a source of monochromatic, coherent, directional radiation, which includes an active substance, pumping source, and a cavity resonator. The interaction of these elements can be graphically seen in the example of operation of a laser (Figure 2.6.3) in which the active substance is a ruby (or other active substance) in the form of a round rod 2, the pumping source is pulse gas-discharge tube 4 with power supply 5, while two parallel mirrors 1 and 3 are the cavity resonator.

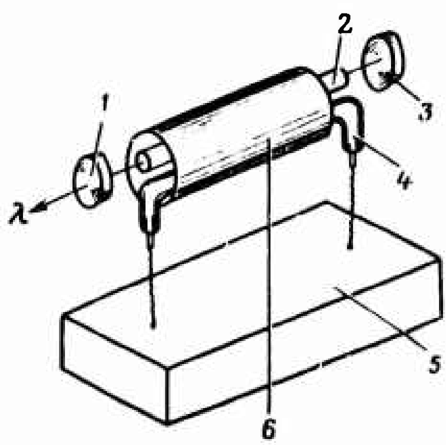


Figure 2.6.3. Schematic Placement of Components of a Simple Laser

Key:
1. Semitransparent mirror
2. Rod (active element)

(Key to Figure 2.6.3 on preceding page, cont'd)

3. Opaque mirror
4. Pulse gas-discharge tube
5. Power supply
6. Reflector

When the gas-discharge tube is actuated, powerful visible radiation briefly occurs. This radiation is concentrated by polished reflector 6 on the ruby. By virtue of the laws of quantum mechanics, the ruby stores a portion of the light energy which strikes it (is excited). In other words the atomic energy of the ruby particles increases.

The state of an active substance with elevated internal energy is always unstable. As a result a reverse process takes place a fraction of a second later: the active substance gives up energy obtained from the pumping source, and under certain conditions the ruby also returns the stored energy in a pulse, but at one strictly defined wavelength, corresponding to the color red.

A qualitative transformation of energy takes place, as it were. The gas-discharge tube randomly generates light across a broad band of wavelengths, while ordered radiation of a single wavelength appears at the laser output, that is, monochromatic radiation. This process is accompanied by substantial losses. Therefore the efficiency of a laser generally does not exceed a few percent.

The cavity resonator causes the laser radiation, multiply reflecting from the mirrors, to return to the excited active substance. There occurs an avalanche-type amplification of the intensity and direction of the light flux. Since mirror 1 is partially transparent, a pulse of optical energy passes through it to the exterior in a narrow beam.

By making the described arrangement somewhat more complex, a laser can produce monochromatic, directed radiation of exceptionally high power. To achieve this, the energy obtained from the pumping source is forced by a special device to be released extremely rapidly -- in billionths of a second. As a result of shortening pulse duration, its power increases almost proportionally.

In spite of the great variety of active substances and the methods of their pumping, all lasers are characterized by properties which are important for practical applications: monochromaticity, directivity, and high pulse power. These properties fundamentally distinguish lasers from conventional light sources (incandescent lmaps, gas discharge lamps, etc) and result in diversified utilization of lasers abroad for military purposes.

As follows from foreign sources, lasers are most extensively utilized for rangefinders in NATO tank troops. Laser rangefinders are considered to be superior to other means of determining distances as regards accuracy and measuring time, ease of learning and utilization, as well as ease of coupling with ballistic computers.

The simplified block diagram of a laser rangefinder (Figure 2.6.4) includes a pulsed laser emitter (transmitter) 2, transmitter focusing optics 1, energy storage in the form of capacitor unit 3, photosensitive detector 9, detector optical system 11, measuring unit 4, range indicator 8, power supply 5, control panel 6, and sight 10.

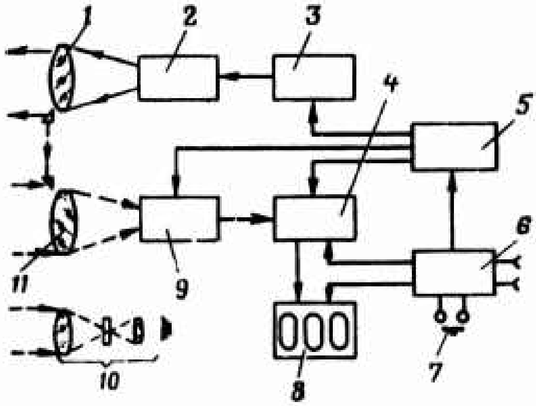


Figure 2.6.4. Simplified Block Diagram of Laser Rangefinder

Key:

1. Focusing optics
2. Pulsed laser emitter
3. Capacitor unit
4. Measuring unit
5. Power supply
6. Control panel
7. Range button
8. Range indicator
9. Photosensitive detector
10. Sight
11. Detector optical system

A simple laser rangefinder operates as follows: after switching on power, the gunner locates a target with the sight and places the special graticule (mark) in his field of view on the target. Since the receiver-transmitter was aligned to the special graticule in advance, the optical axes of the laser and of the photodetector are aimed precisely at the selected target.

The gunner then pushes the range button on the control panel. The electrical energy stored in the bank of capacitors is applied to the pulsed pumping tube. As a result the active substance is intensively irradiated by a pulse of visible light, under the effect of which a powerful monochromatic, directed laser radiation is briefly produced. The transmitter optics additionally focus this radiation into a very narrow beam of light which is directed toward the target. Simultaneously a slight portion of the laser pulse enters the photodetector, where it is converted into an amplified electrical signal. This signal is applied to the measuring unit and triggers an electronic time counter. The laser beam in turn reaches the target and is reflected by it. A certain portion of the reflected energy returns to the rangefinder and is focused by the optical system on the photodetector. Following practically instantaneous conversion and amplification, the reflected signal stops the measuring unit time counter.

Thus duration of laser radiation travel to the target and back is recorded. On the basis of the recorded time and the known speed of light, within a fraction of a second the measuring unit electronic circuitry computes range to target. Computation results are displayed in digital form on the indicator glow tubes.

Usually the indicator is incorporated into the sight optical arrangement so that the numbers are visible in the sight field or in the field of an additional eyepiece.

Some foreign-built rangefinders have two indicators and two control panels. The backup indicator and control panel are positioned by the tank commander. When necessary the commander can take over from the gunner operation of the rangefinder and independently prepare initial firing data. Foreign experts claim that with parallel employment of two or three measuring units it is possible to obtain simultaneous rangefinding and display on rangefinder indicators of the ranges of two or three objects struck by the laser beam in the course of a single emission pulse. The gunner compares the ranges obtained with the rangefinder and the corresponding objects visible in the sight, and then chooses the correct measurement result, that is, the result which applies to the specific target. This eliminates spurious triggering of the laser rangefinder by beam reflection from chance targets and local features positioned on the line of sight.

Some rangefinders on modern foreign tanks not only give a digital display of the measured range but also generate a voltage proportional to that range, which is fed into the tank fire control system electronic ballistic computer as well as into the automatic sight scale (mark) setting device and into the gun drives. Laser rangefinders are made in periscopic and telescopic versions. The optical assemblies of the receiver-transmitter and sight are made both independent and with common elements. The rangefinder emitter and photodetector, together with optical systems, are exterior-mounted on the tank gun or inside the turret. In the latter instance a special aperture in the armor or the port for one of the armored vehicle's optical instruments is used for laser emission and receiving reflected signals.

Laser rangefinders with the following basic specifications are manufactured in quantity for the tank troops of the NATO nations:

maximum effective range 5-10 km;

accuracy of measurement ±(5-10) m;

maximum frequency of measurement 3-30 per minute;

weight of unit 15-50 kg.

The high operating efficiency of individual laser rangefinders is tested and maintained by a system of built-in monitoring of the principal performance specifications of the receiver-transmitter and measuring unit.

In addition to rangefinders, laser firing and target hit simulators are extensively employed abroad. At two-sided exercises delivery of fire by the opposing sides is simulated with their aid, which brings the training troops closer to an actual combat situation. The technical and tactical proficiency both of individual crews and units are comprehensively improved under these conditions. In addition, an "enemy" tank or gun "kill" is objectively recorded, with accurate preparation of initial firing data and correct actions by vehicle or weapon crews.

The nucleus of firing and target hit simulators is a laser emitter with low-power pulses, mounted on each weapon and aligned with it. The simulator also includes several photodetectors, mounted on these same weapons, in combination with an electronic logic unit.

In the general case simulators operate as follows: an expendable quota of "rounds" (pulses) and a maximum rate of fire are specified for each type of weapon. While performing a tactical mission a gunner, detecting a target, determines range to it, speed and direction of mutual displacement, as well as external firing conditions. The gunner then feeds the requisite data into the fire control system, aims and presses the gun electric trigger button. A special pyrotechnic cartridge is ignited, simulating the flame and cloud of dust and smoke which give away a tank's position. Simultaneously the laser of the "firing" unit sends a directional optical emission to the target; a special device takes into account that a shell or bullet expends an appreciable time en route to the target and describes a curved trajectory, while the laser beam travels to the target straight and instantaneously.

If initial firing data have been prepared and fed in correctly, and aiming is accurate, the laser beam strikes one of the photodetectors mounted on the "aggressor" combat vehicle or gun.

Then, depending on range and point of beam hit, the logic unit of the target which has taken fire determines whether it has been "killed." A target "kill" is accompanied by igniting of a signal smoke pot on the target. Automatic control circuits simultaneously block the laser of the disabled vehicle and thus prevent its further participation in the exercise. In addition, light and sound signals are triggered in the "destroyed" tank, informing the crew of the results of the engagement.

According to comments in the foreign press, laser firing and kill simulators create at an exercise a situation approximating actual combat and make it possible to trace development of the "battle" with certainty and to evaluate employed tactics. Thanks to this, opposition by the "adversary" is objectively taken into account, development of vehicle crew coordinated performance is more efficient, tactically effective unit combat formations are developed more easily, and new tactics of performance of combat mission by the unit are mastered more rapidly.

It is claimed in the foreign press that laser simulators for gunnery training without expending ammunition are the simplest version of the equipment described above. A pulsed laser is used in conjunction with the gun or machinegun, with the gunner firing at the target by laser beam. Photodetectors are placed at various points on the target receiving fire. Triggering of one of these photodetectors makes it possible to judge the accuracy of fire and time expended on firing. It is also easier to zero in tank weapons with the aid of a simulator. Employment of laser simulators reduces the time and cost of personnel gunnery training, and there is also no need for large firing ranges.

Of laser devices suitable for utilization in the military, high marks are also given abroad to missile guidance systems for placing missiles on small and distant targets. The system operates on the following principle: the operator locates the target with the sight, makes the decision to destroy it, switches on the laser and "illuminates" the target with its beam. Illumination is provided by either visible or infrared radiation. As a result a spot 1-2 meters in diameter forms on

the selected target, which served as a reference point for missile homing guidance. A portion of the laser emission is reflected by the target in the direction of the launcher and is picked up by a photosensitive device on the missile. The missile is then fired. At the same time the reflected signal, striking the photodetector, is converted, amplified, interpreted if necessary, and acts on the missile control surfaces via an automatic control unit. As a result the missile's flight trajectory is altered in such a manner that firing errors are reduced and target kill probability is appreciably increased.

In addition, it has been reported in foreign publications that a laser system is being developed for guiding artillery projectiles only in the final segment of their trajectory, as well as utilization of a system for intensive pulsed illumination of terrain, increasing the effective range of active night vision devices, and for target identification.

SECTION III. WHEELED ARMORED VEHICLES

Chapter 1. DEVELOPMENT OF WHEELED ARMORED VEHICLES

The problem of utilization of wheeled armored vehicles for military purposes arose simultaneously with the appearance of the automobile. In the first period of development, armored cars were made by placing an armored body on the frame of an appropriate civilian motor vehicle with very minor chassis modification. This method of building armored cars proved effective at the early stage of development of wheeled vehicles. With increased performance demands on wheeled armored vehicles, in many cases this method led to discrediting of the very idea of building combat vehicles on a wheeled chassis.

Inasmuch as wheeled armored vehicles (WAV) became a mass-use combat vehicle in World War II, the advisability of closely linking its manufacture with the automotive industry became obvious. Therefore the "direct standardization" method in building WAVs of various types became quite widespread abroad at the very outset of the postwar period. What this means is that a wheeled armored vehicle retains the general layout of a multipurpose army motor vehicle adopted as base vehicle. The components of this vehicle are fully utilized, or with minor modifications, in the vehicle's structural armored body. Examples of armored personnel carriers which have utilized to a great degree series-built automotive production components include U.S. wheeled armored personnel carriers, the Dutch postwar YP-408 armored personnel carriers, etc.

However, with armored vehicles based directly on multipurpose military motor vehicles already being built by the automotive industry, conflicts arise between demands on design and construction of components and systems for a WAV and for multipurpose vehicles. In the opinion of foreign experts, the direct standardization method, while good from manufacturing and economic aspects, fundamentally complicate the development of combat vehicles with excellent combat performance characteristics.

Thus direct standardization of civilian motor vehicles and WAV, in the opinion of foreign experts, is not warranted at the present stage of development of combat vehicles. It is therefore believed that vehicles meeting higher performance requirements should have a specific layout and certain special components. Out of economic considerations, however, the main automotive production components and parts and the production facilities and manufacturing processes of the automotive industry should be utilized.

A large number of WAV models of various types were developed in the postwar period according to this principle, in particular the U.S. Commando and Dutch DAF-408 armored personnel carriers, plus others. The Panard combat reconnaissance vehicle can serve as an example of a combat vehicle in which the principle of specialization of design was utilized most fully and all principal components and general layout were developed taking into account imposed tough performance requirements. This vehicle has excellent performance characteristics, but its cost proved quite high.

Today's highly mechanized army requires such great expenditures of manpower and resources that even in the economically most highly developed countries the aspects of achieving savings in furnishing the military combat equipment play a primary role. This is the reason for a trend abroad, clearly marked under present-day conditions, toward linking as closely as possible the development of general civilian wheeled vehicles with the demands imposed on WAV of various types.

In recent years there has occurred a trend abroad toward "reverse" standardization and the development of large "families" of vehicles. In this instance, on the instructions of or under the direction of military agencies, a general "family" of wheeled vehicles is developed, which includes WAV and general-purpose army trucks. The overall development project is based on the most complex armored vehicle, the elements of which become the base for army motor vehicles and subsequently for commercial vehicles as well. The development portrayed in Figure 3.1.1 is an example of such a "family" (FRG).

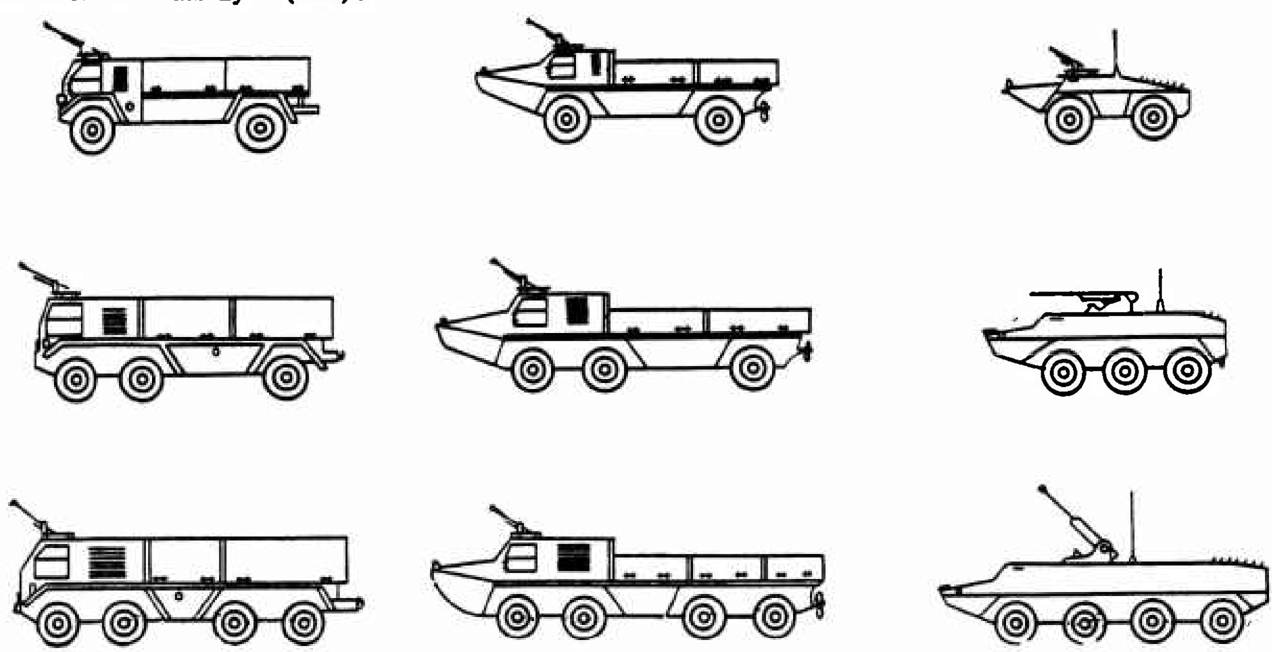


Figure 3.1.1. Types of Wheeled Armored Vehicles and Multipurpose Army Trucks

The "family" includes four-, three-, and two-axle WAV. The four-axle vehicle is designed as a combat reconnaissance vehicle. An infantry armored personnel carrier, a staff version of an armored personnel carrier, and other types of armored cars are based on other chassis. The "family" also includes 4, 7 and 10 ton

multipurpose trucks and corresponding wheeled amphibians. Characteristic of these vehicles is identical basic layouts, armament on the military vehicles, and sealed cabs. The "family" incorporates considerable standardization of vehicle equipment and systems. The entire "family," for example, employs the same 14.00-20 tire, and there is standardization of suspension parts and transmission components to a significant degree as well. Armored vehicles have automatic transmissions, and army trucks have partially-automatic transmission. The vehicles of this "family" are high-powered and fast. Power-to-weight ratio is more than 20 horsepower per ton, top speeds are not less than 80 km/h, and range is up to 800 km.

The vehicles of this "family" comprise approximately 50 percent of all military wheeled vehicles, approximately 80 percent of total load-carrying capacity, and approximately 75 percent of the total cost of the wheeled vehicle fleet. The vehicles are designed for a service life of 15-20 years; time between major overhauls should be 150,000 km for military trucks, and 90,000 km for armored vehicles.

The idea of multipurpose utilization of a standardized chassis was embodied in the UR-416 "family" of armored vehicles (Figure 3.1.2). This "family" is based on the chassis of the Unimog two-axle all-wheel drive army truck, which is suited for mounting armored bodies of various type, depending on the vehicle's role. The bodies of differing roles have standard fastenings and identical design and construction for a large number of components.

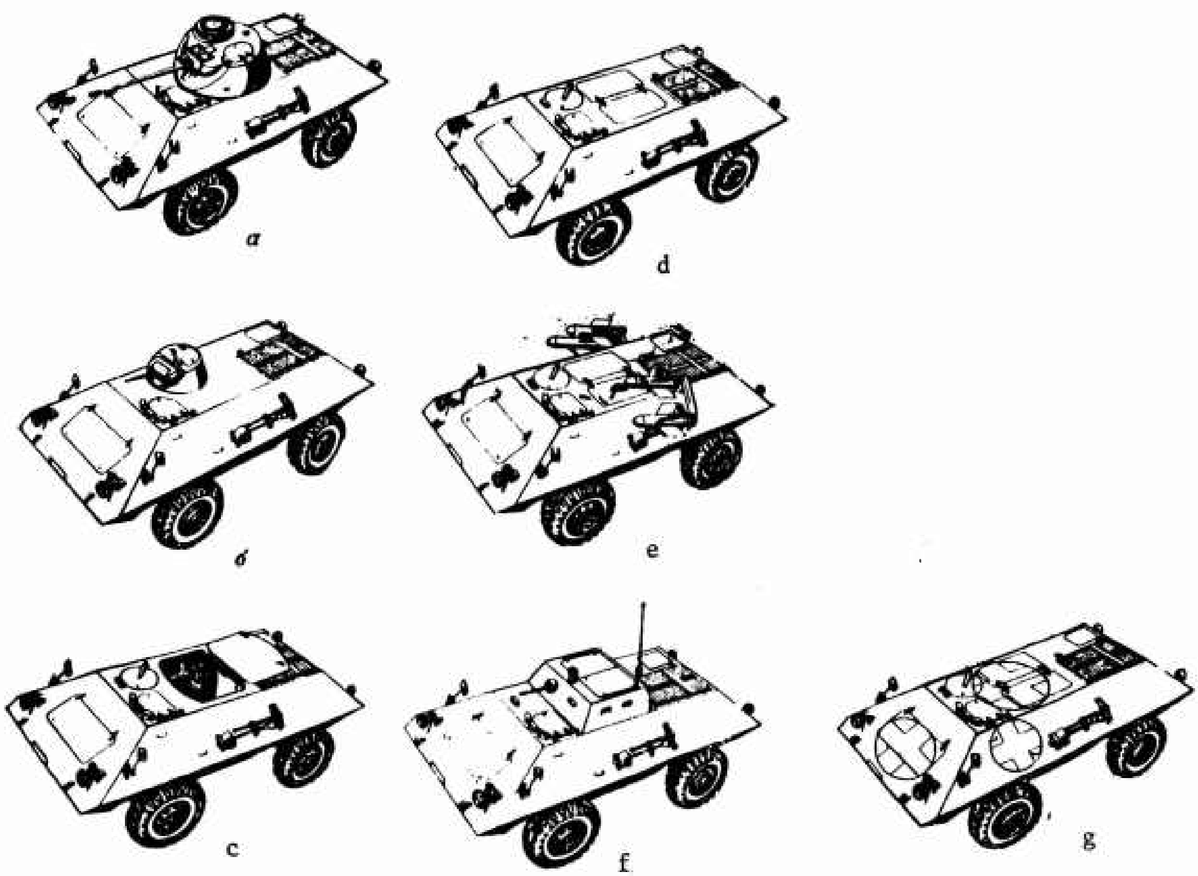


Figure 3.1.2. "Family" of Wheeled Armored Vehicles on a Standardized Chassis

The family of armored vehicles includes the following: a combat reconnaissance vehicle (Figure 3.1.2a), carrying a three-four man crew, armed with a 20 mm automatic gun and coaxially mounted machinegun; an armored personnel carrier carrying 9 men with machinegun armament in the turret (Figure 3.1.2b); an armored personnel carrier with an 81 mm mortar (Figure 3.1.2c); an armored carrier for hauling personnel or supplies (Figure 3.1.2d); an armored vehicle armed with antitank or antiaircraft missiles (Figure 3.1.2e); a command vehicle (Figure 3.1.2f) and, finally, a WAV with a three-man crew for medical evacuation (Figure 3.1.2g) of four wounded.

All these WAV have a hull height of 1,700 mm, road clearance of 430 mm, and carry 14.5-20 tires. A 200 horsepower engine provides a power-to-weight ratio of more than 20 hp/t, which gives high mobility. The powerplant and transmission are contained in a sealed, soundproof and heat-insulated compartment. The different versions of this vehicle weigh from 7.5 to 8.5 tons, which makes them air-transportable. In the opinion of foreign experts, however, employment of a single common two-axle chassis in a family, while resolving well the economic aspects of developing vehicles of different types, basically cannot provide the requisite degree of mobility and capability to negotiate various obstacles, including trenches, for such types of WAV as combat reconnaissance vehicles. Herein lies a general drawback of very extensive employment of a single chassis.

Foreign experts believe that theoretically it would be ideal to have a special vehicle to perform each type of mission, a vehicle which would correspond most fully to the imposed demands. This is not practically possible, however, due to the extremely high cost of a fleet of such vehicles and the complexity of logistical support.

Study of the entire aggregate of problems led foreign experts to the conclusion that their solution lies in developing a flexible family of WAV, capable of reliably performing various missions but essentially requiring identical logistical support.

As reported in foreign publications, such a project was accomplished by the French company Panard, which proposed a family of WAV with 4 x 4, 6 x 6, and 6 x 8 chassis. The main provisions adopted in this development project included the requirement of a high level of standardization, whereby all vehicles in the family should use practically the same replacement-requiring parts, a capability of common training of servicing and maintenance personnel, while technical documentation should be identical for all vehicles in the family.

The vehicles of this family have basically the same common layout. The driver and engine compartment are located in the forward part of the hull. The vehicle commander is positioned behind the driver's seat. The trooper compartment is located in the middle and rear portions of the hull. Depending on the vehicle's role, the interior equipment and layout can be modified for utilization as command vehicles, air defense vehicles, ambulances, etc.

Vehicle powerplants are standardized to a significant degree within the family of vehicles and differ only in piston stroke as well as certain changes in clutch mechanisms and gearbox for the 4 x 4 and 8 x 8 chassis. The final drive gears are identical for all vehicles, with the exception of the drive to the right and left steerable wheels. The flexible suspension components and shock absorbers are connected to the individual wheels, and therefore they are of identical design for all

vehicles. Electrical equipment, supplementary equipment and control systems are standardized with the family.

All existing AML wheeled armored vehicle turrets can be mounted on the vehicles, including a new turret with twin-mounted 20 mm automatic guns; a three-man turret with a 105 mm gun can be mounted on the 8 x 8 chassis. The vehicles are comparatively well protected. Thickness of the frontal armor is 25 mm (sloped at 45-60°), side armor -- 13-15 mm, hull roof and floor -- 8 mm, which, with efficient hull shapes, protects them against small-arms fire, and the hull front against small-caliber guns at normal combat range.

The design of these WAV incorporates the majority of known modern solutions for increasing vehicle mobility. Engines develop maximum horsepower of 200-250 hp and boast a power-to-weight ratio of approximately 20 hp/t. The transmission features self-blocking differentials, including the final drive differential.

Increased mobility and economy of four-axle vehicles during on-road movements is promoted by wheel-raising capability, with the aid of a hydropneumatic suspension, quick-change capability from four-axle to two-axle drive, and ease of operation.

The new Panard vehicles feature a hydromechanical gearbox, while a transfer case permits utilization of a lower range of gears when driving cross-country and a higher range when traveling on roads. Maximum speed is 80 km/h, with an on-road range of 1,000-1,200 km. All vehicles of the new family can float without additional preparation. Propulsion and steering afloat are provided by the wheels. The design provides for installing screw propellers on modified versions and increasing swimming speed to 6-7 km/h. The ability of vehicles to negotiate obstacles depends on the number of axles. A two-axle vehicle can cross a ditch 1.1 m wide and can negotiate a 0.45 m vertical obstacle. A three-axle vehicle can cross a ditch 1.9 m wide and a four-axle vehicle -- up to 2.2 m wide. A four-axle vehicle has a ground pressure of somewhat less than 1 kg/cm^2, which means excellent soft-ground capability.

All vehicles have hydropneumatic suspension and a variable ground clearance system, from 210 to 470 mm. The vehicles employ bullet-resisting tires of identical size. In designing the vehicles in this family, considerable attention was focused on meeting the demands of ergonomics and design for ensuring crew operating efficiency, especially during extended travel. The effect of jolts and vibrations when traveling cross-country is diminished to a considerable degree by employing a soft hydropneumatic suspension. In order to reduce the noise level, the powerplant is surrounded by sound and thermal insulation, and the hull interior walls are covered with a sound-absorbing layer. The vehicles are equipped with filter-ventilation units. Some vehicles can accommodate air conditioners operating off separate small motors. An air conditioner can maintain the interior temperature at 20-25°C with outside temperature ranging from -15 to +50°C.

Much attention was devoted to improving observation conditions for driver and troopers and to make vehicle mounting convenient for them. Servo units are extensively employed in the vehicle control systems.

Thus today principal attention is being devoted in foreign practices to the development of efficient, flexible families of armored vehicles, rather than individual models with superior performance characteristics.

In the improvement of WAV, in the opinion of foreign experts, one can note general patterns characteristic of the developed capitalist countries. Principal directions of development include standardization of vehicle components, improvement of auxiliaries and systems with a generally traditional layout, and parallel work in the area of new arrangements. For all types of vehicles mobility is being increased chiefly by improving cross-country performance, providing ditch-crossing and swimming capability, hull protection is improving, and further strengthening of armament is taking place.

Chapter 2. GENERAL LAYOUT OF WHEELED ARMORED VEHICLES

General layout of WAV includes mutual placement of crew members, armament, principal equipment and systems, subordinated to the task of ensuring specified combat performance characteristics.

The principal compartments of a WAV are the trooper (fighting) compartment, the driving compartment, and the engine compartment. Sometimes there may be a separate transmission compartment. Figure 3.2.1 contains variant arrangements of compartments in WAV of different types.

The general layout of a WAV should correspond to requirements proceeding from its role and the character of its utilization.

Convenient positioning and movement of crew members, as well as requisite habitability conditions should be provided within the armored hull. The adopted layout determines to a considerable degree hull weight and size, efficient utilization of interior spaces and areas, good visibility and convenience in delivering fire from organic and personal weapons, conditions of dismounting assault troopers and interaction between crew members.

Layout greatly affects a vehicle's protective characteristics, its cross-country performance, economy, smoothness of ride, ease of operation and maintenance, plus other performance characteristics. Important elements for the layout of a WAV, other than role and type of armament, include size and placement of crew, type and placement of powerplant, transmission, suspension, and characteristics of the wheel drive.

Crew size for wheeled combat reconnaissance vehicles ranges from two to four, while armored personnel carriers and infantry combat vehicles carry from 9 to 12 persons. Armored carriers used for the logistical support role can have a larger capacity.

The powerplant can be located in the forward, rear or middle portion of the WAV hull. Powerplant forward placement is typical for combat vehicles based on the chassis of army general-purpose trucks (Figure 3.2.1a, c), while rear placement is typical of combat reconnaissance and wheeled amphibious vehicles (Figure 3.2.1d, f, g). Sometimes two motors are mounted on a WAV chassis. As a rule two identical motors are employed, but in some models one of the motors is the main powerplant, while the other, smaller-horsepower motor is a booster and is fired up to increase tractive force on the wheels under difficult road conditions. Sometimes a booster

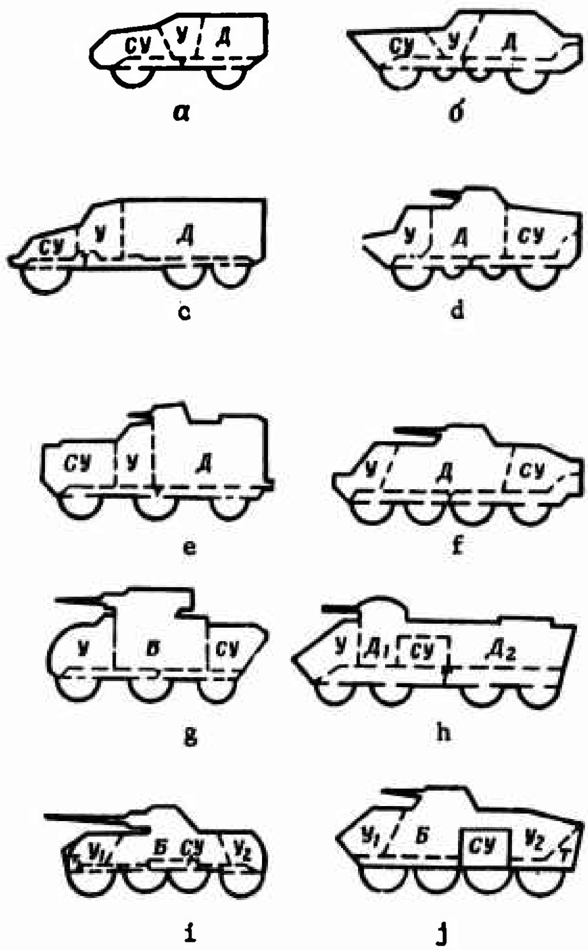


Figure 3.2.1. Possible Layouts of Wheeled Armored Vehicles

CY -- engine; Y -- driving; Д -- trooper; Б -- fighting; Т -- transmission

motor is used as a power source for driving auxiliaries and charging batteries. With this arrangement, the main engine can be used exclusively for powering the WAV.

Placing the powerplant in the middle portion of the hull can give good layout results only if the engine is not very tall (Figure 3.2.1i). If an engine with vertical or V cylinder arrangement is placed in the middle portion of the hull, it is difficult for crew members to move about the vehicle interior (Figure 3.2.1h, j).

A vehicle's layout characteristics are determined not only by the location of the powerplant but also by type of engine. Foreign experts are of the opinion that a carburator engine is not fully satisfactory to designers of WAV. Therefore intensive work is in progress in the area of improving engines, boosting performance, increasing low-temperature startup reliability, reducing noise, as well as in certain other areas.

Diesel and multifuel engines are coming into increasingly more widespread use. Liquid-cooled engines, as they are less noisy, are employed on armored vehicles, especially combat reconnaissance vehicles.

Transmission. The layout arrangements of transmissions are quite diversified and depend on the type of WAV and its role. Based on the location of the principal components and the arrangement for applying power to the driving wheels, transmissions are subdivided into central (axle-differential type) and outside (H-type).

Central (axle-differential) transmission arrangements are extensively employed on combat vehicles which are based on corresponding multirole all-wheel drive army trucks. Outside (H-type) transmission arrangements are employed on special WAV chasses.

Figure 3.2.2 shows the transmission layout on a number of WAV. The transmission of a WAV as a wheeled vehicle with excellent cross-country performance should provide capability to change tractive effort on wheels and speed across a broader range than conventional cars and trucks, as well as application of torque to all wheels. For this reason the transmission systems of all-wheel drive vehicles are more complex; they include a transfer case, from which torque is distributed between axle drives.

One specific feature of WAV transmission systems is the presence of mechanisms to take off power from the transmission system to drive various accessory equipment and special devices. The diagram (Figure 3.2.2a) shows power takeoff from the gearbox to power a winch. The special demands imposed on armored vehicles, even with the extensive utilization of series-built truck components in their manufacture, frequently make it necessary to reject traditional transmission system arrangements and layouts.

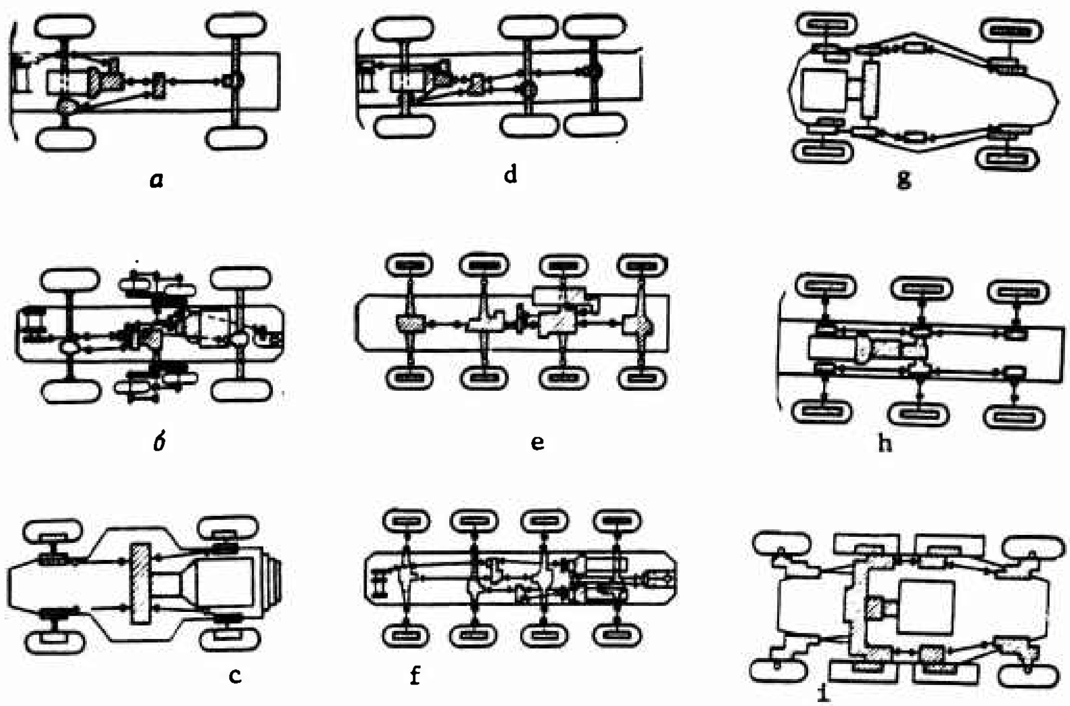


Figure 3.2.2. Diagrams of Transmission System Layouts of Wheeled Armored Vehicles

Figure 3.2.2b shows a transmission system arrangement for an armored scout-reconnaissance vehicle. To give the vehicle capability to cross trenches and other such obstacles, two pairs of retractable supplementary drive wheels are mounted between the main axles. These wheels are driven by a special power takeoff via shaft and chain drives. The extra wheels are lowered only when negotiating obstacles.

For on-water propulsion there is a water jet, driven by a power takeoff via a shaft drive and reduction gear built into the water jet unit. There is a hydraulic pump on the power takeoff for controlling lowering and retracting of the extra wheels and splash board, and for the power steering system. Power is applied to the winch from an additional reduction gear via shaft drive.

Figure 3.2.2c contains a transmission system diagram for a nonamphibious reconnaissance vehicle with the engine positioned in the rear part of the hull. One specific feature of this arrangement is individual power linkage from the transfer case to each driving wheel via angular reduction gears and shaft drives. The wheels carry planetary-type wheel reduction gears.

The transmission systems of three-axle wheeled vehicles are distinguished by diversity of layouts and arrangements. Torque to the middle and rear driving axles on three-axle wheeled vehicles can be transmitted from a single transfer case shaft via shaft drives sequentially to the middle axle drive and from it to the rear axle drive or from different shafts via separate shaft drives (Figure 3.2.2d). The transfer cases of three-axle vehicles contain a mechanism to disengage front axle drive, or an interaxle differential is employed, which distributes torque in a specified proportion between the front and two rear axles.

Figure 3.2.2e contains a diagram of a four-axle transmission system layout with all-drive and all wheels steerable on a combat reconnaissance vehicle. A specific feature of the general layout of this vehicle is placement of the engine in the middle portion of the hull. Torque is transmitted from the engine via a hydro-mechanical gearbox and additional reduction gear to a transfer case, which distributes torque between the first and second, third and fourth axles.

Straight-through shafts are provided in the central reduction gears of the final drive for the second and third axles, transferring power to the final drives of the first and fourth axles respectively, as well interwheel differentials with forced interlocking. Suspension is conventional. Torque is transferred to the wheel reduction gears via half-axles with shafts, which turn the wheels relative to the axle pins. Planetary-type reduction gears are employed on the wheels. This arrangement is used on heavy WAV.

Figure 3.2.2f shows a transmission system layout for an armored personnel carrier which has two engines together with clutches and gearboxes, positioned in the hull. The transmission system consists of two sets of units, each of which is a transmission system for a two-axle wheeled vehicle with all-wheel drive. Employment of two engines and such a transmission system arrangement makes it possible to utilize for a heavy four-axle armored personnel carrier certain relatively lightweight and small components of mass-produced trucks. All mechanisms of the armored personnel carrier transmission system, with the exception of the wheel reduction gears and connecting shaft drives, are contained inside the watertight hull.

All the above transmission system arrangements are of the axle-drive type. Some types of vehicles, however, employ outside and H-type transmission system arrangements with power distribution along the side of the vehicle. Figure 3.2.2g, h, and i contain examples of transmission system layouts of the H-type and outside type. Employment of an H-type transmission system arrangement makes it possible to lower the floor in the driving compartment, to place the driver's seat on the hull floor, as a result of which hull height is reduced and a flat, even floor is obtained.

Figure 3.2.2g contains a diagram of the layout of a H-type transmission system on a light combat reconnaissance vehicle, while Figure 3.2.2h shows a similar arrangement for a three-axle armored personnel carrier. The vehicle's engine is mounted in the forward part of the hull. Torque is transmitted from the engine via clutch and gearbox to a transfer case and to final-drive reduction gears. In this instance the final drive, reversing mechanism and differential are grouped in the transfer case. Since the vehicle has independent suspension, torque is transferred from the reduction gears to the wheels via a shaft drive, and in this arrangement the wheels of the two forward axles are steerable.

Figure 3.2.2i shows an H-type transmission system layout on a heavy four-axle combat reconnaissance vehicle.

As is evident from the diagrams, outside and H-type transmission systems are complex. The large number of mechanisms increases the weight of the transmission system and transmission losses. In addition, the absence in some cases of differential linkages between right and left wheels as well as between wheels on the same side, under certain conditions of movement, causes elevated circulation loads within the transmission system, which leads to additional wear on transmission mechanisms and tires as well as greater fuel consumption.

A mechanical transmission is employed on the majority of WAV, which is fairly complex for multiaxle all-wheel drive vehicles and leads to increased mechanical losses and greater complexity of operation. Therefore the principal directions in the improvement and development of transmission systems are reduction of transmission system losses and easing vehicle operation.

Mechanical losses are reduced by increasing the efficiency of all transmission components by design and engineering improvements on separate assemblies, selection of an efficient transmission system arrangement, and disengagement or even retraction of some of the driving wheels during operation in good road conditions.

Automation of driving control is being employed more and more frequently on WAV, just as on tanks, to ease operation of mechanical transmission systems, and remote controls are being developed. An automatic hydromechanical transmission system is employed on a number of modern WAV as a means of easing operating control and increasing vehicle average speeds.

Running gear. The characteristics of wheel drive exert considerable influence on overall running gear layout. In selecting a wheel drive one proceeds from factors of load-carrying capability, securing preselected parameters of cross-country performance and tractive capability, as well as considerations of combat survivability.

Figure 3.2.3 contains diagrams of wheeled vehicle layouts. The most common are 4 x 4, 6 x 6, and 8 x 8 (Figure 3.2.3a, b, c).

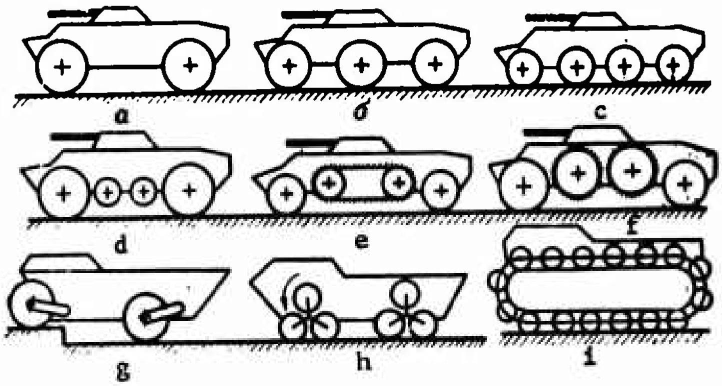


Figure 3.2.3. Basic Diagrams of Wheel and Combination Drive

Two-axle WAV generally weigh up to 9 tons. One advantage of a two-axle layout is good utilization of interior space between axles. Additional advantages of a two-axle arrangement include simplification of transmission system, with extensive possibilities of employing components from mass-produced vehicles and simplification of control mechanisms.

Medium and heavy armored vehicles are three-axle. Axle configuration exerts considerable influence on vehicle layout. The axles can be configured as on a three-axle truck, where the rear axles are close together while the wheels on the front axle are steerable (Soviet BRT-152), or the axles are uniformly spaced on the chassis, while either the wheels on the front two axles are steerable (British Saracen APC), or the front and rear axles. A vehicle with rear axles close together has layout advantages: it can employ a conventional drive axle arrangement. As a rule vehicles with uniform axle placement have transmission system elements positioned along the sides. Three-axle vehicles with uniform axle placement possess certain advantages in negotiating ditches.

The four-axle arrangement is typical of modern medium and heavy WAV. This arrangement is distinguished by complexity of transmission system and running gear. It is characterized by comparatively large losses in the transmission system and running gear. Four-axle vehicles, however, are becoming increasingly more widespread, due to the excllent cross-country performance of these vehicles as a consequence of capability of transferring substantial tractive effort with low ground pressures (to 0.7-0.8 kg/cm^2), as well as the capability, characteristic of such vehicles, to negotiate trenches and ditches of considerable width. An additional advantage of this arrangement is greater vehicle combat survivability, since the vehicle can continue moving with one or two wheels damaged.

The layout arrangement of four-axle vehicles is greatly dependent on wheel placement along the chassis and number of steerable wheels, as well as on wheel size. Four-axle vehicles usually have only two pairs of steerable wheels.

Combined drives have become increasingly more widespread on WAV in recent years, incorporating two or several drive arrangements. Employment of a combination drive

makes it possible to improve certain vehicle performance characteristics, particularly mobility.

The Soviet armored reconnaissance-scout vehicle employs a 4 x 4 drive arrangement with four auxiliary wheels (Figure 3.2.3d), which are lowered for crossing ditches. The auxiliary wheels are intended for brief use only when negotiating ditches, and therefore they carry small, high-pressure tires.

Auxiliary middle wheels can be replaced by an auxiliary track drive (Figure 3.2.3e). A wheel-track drive provides high overall drive versatility, increases traction capabilities, and broadens the range of soil conditions under which WAV can be successfully employed.

There are combination drive arrangements which seek to exploit the advantages of a four-axle layout and at the same time minimize its drawbacks (Figure 3.2.3f). The French Panard four-axle armored vehicle can raise its middle wheels when traveling on a good road, which substantially reduces power lost to rolling resistance. When moving on soft, wet ground the middle wheels, carrying metal lugs, are lowered, which greatly increases traction and mobility under these conditions.

Increasing demands on mobility have led to the creation of new, complex drive arrangements adapted for operating on soils with very low supporting capability and permitting negotiation of various obstacles.

A wheeled-walking drive (Figure 3.2.3g) is distinguished by the fact that the driving wheels are mounted on long levers, inside which power runs to the wheels. When necessary, the levers can rotate in their supports, and the vehicle advances by walking, which provides the capability to negotiate difficult terrain and various obstacles. Ground clearance can be varied by placing the levers in different positions, and this same technique can be used to keep the hull horizontal while moving on a slope.

An arrangement with triple-roller wheels (Figure 3.2.3h), when traveling on a good road, is analogous to an 8 x 8 wheeled drive, while in difficult conditions, with such compound wheels rotating as a single unit, good soft-ground capability is obtained.

A roller-track arrangement (Figure 3.2.3i) gives good cross-country performance on swampy terrain and unpacked snow. During travel on hard-surface roads, the pneumatic rollers turn on their axles, rolling along the hull, and the nature of interaction between drive and road is the same as that of a conventional multiwheel arrangement. When moving on soft ground the rollers do not rotate, and the arrangement operates as a track drive. The rollers perform the function of the track links. As a consequence of the large volume of soil held between rollers, good traction with the ground (snow) is ensured, as well as a capability to apply considerable tractive effort.

One of the principal drawbacks of such WAV is diminished running gear battlefield survivability. This problem arose as soon as wheeled vehicles with pneumatic tires began to be employed as combat vehicles.

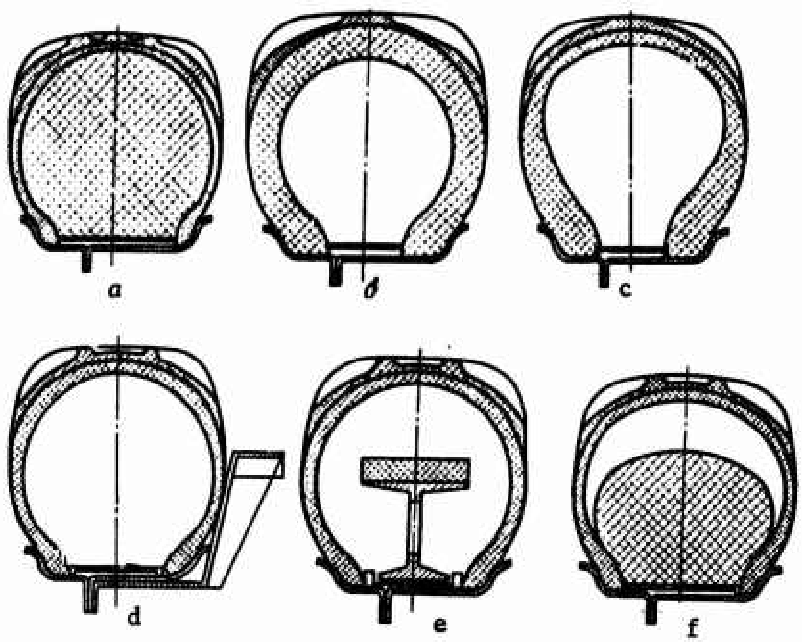


Figure 3.2.4. Types of Bullet-Resistant Tires

The problem of building bullet-resistant tires is being attacked from a number of directions. Tires with a foam rubber filler were employed rather extensively in the prewar years (Figure 3.2.4a), but they limited speed and contained other significant operational disadvantages, and for this reason they are not used on armored vehicles today. Thick-walled (Figure 3.2.4b) self-sealing tires and tires with sectioned tubes did not fully meet demands and were not extensively employed.

In the search for ways to improve the cross-country performance of wheeled vehicles, engineers arrived at adjustable-pressure tires. At the same time this system made it possible to increase tire survivability by pumping up to pressure upon taking damage, especially with tubeless tires. Employment of a tire pressure adjustment system does not fully solve the problem of survivability. In a number of countries this problem has been attacked in recent years by combined employment of a tire pressure adjustment system and special devices making it possible to keep a vehicle moving even with "zero" tire pressure.

A tire with variable carcass thickness (Figure 3.2 4c) is characterized by elasticity, which ensures vehicle cross-country performance. When a tire is damaged, its deformation is limited by the thick beads, as a result of which the vehicle can continue moving at reduced speed.

Figure 3.2.4d shows a tire, deformation of which upon receiving damage is limited by an external limiting device. In this design the limiting device is also a protective device as well as a device for improving cross-country performance. Wheel traction increases on soft ground because of the special radial ribs on the limiter disk.

An adjustable-pressure tire with a tire deformation limiter mounted on the rim with a sliding bearing (Figure 3.2.4e) possesses excellent performance characteristics in an undamaged condition, while with damage it retains capability to operate for an extended time at reduced speed. Load is transmitted from tire to rim through the deformation limiter. A combination pneumatic-sponge rubber tire (Figure 3.2.4f) contains two tubes: a pneumatic and a sponge-rubber tube, with the latter pressed to the rim by air pressure in the pneumatic tube. In undamaged condition such a tire has performance characteristics close to those of the conventional pneumatic tire, but pressure adjustment capabilities in such a tire are limited. When a tire is damaged, compressed air is expelled from the pneumatic tube, and the tire interior cavity fills with sponge rubber. This permits the vehicle to move at reduced speed.

Armored hull layout and crew placement. The armored hulls of modern armored vehicles are carrier-type, open and enclosed. In designing hull layout one must take into consideration convenience in crew and trooper placement as well as requirements on hull protection and weight.

Armored personnel carrier requirements usually specify protection against small-arms fire within an angle of approach of ±45° from all ranges, and therefore the actual thickness of armor in the frontal portion of the hull is usually 10-15 mm. In the opinion of foreign experts, armor thickness for combat reconnaissance vehicles can be increased to 25-40 mm. Approximately the same protection requirements apply to the hull of a wheeled infantry combat vehicle. In most cases thickness of hull side plates is approximately half that of front plates. Rear plates are of even less thickness. Hull roof and floor plates are of the least thickness. Turret protection requirements are equivalent to those of the hull front.

Engineers seek to provide a reasonable combination of protective properties and simplicity of hull shapes. Hull shapes and size for amphibious vehicles should ensure suitable displacement, minimal resistance to movement in the water, and in particular special attention should be focused on the shape of the hull nose.

Modern WAV should permit crew and troopers to remain in the vehicle for an extended period of time without tiring greatly, which demands that particular attention be devoted to convenience and comfort of crew positioning within the hull. For comfortably accommodating troopers, the height of the trooper compartment should be 1,300-1,350 mm, seat height 250-350 mm, seat width not less than 400-430 mm, and depth 320-350 mm. Minimum spacing from seat to hull roof should be 900-950 mm. Minimum width of the lower part of the hull with two-row trooper placement is 1,400-1,450 mm.

WAV layout weight figures. They include relative weight, specific metal consumption, axle weight distribution, and combat weight.

Relative weight expresses the correlation between the weight of WAV component groups, that is, the percentage share in total weight of those components which provide a given vehicle performance characteristic. Depending on WAV type, weight relationships vary. For armored personnel carriers hull weight comprises 30-33 percent of the vehicle's combat weight. Hull weight for combat reconnaissance vehicles ranges from 35 to 45 percent, in connection with increased protection; APC armament weight

comprises 3-5 percent, while it is 8-11 percent for combat reconnaissance vehicles, in connection with increased firepower.

The relative weight of powerplant and transmission system for a WAV is 19-22 percent and running gear -- 17-20 percent. The relative weight of additional equipment varies within broad limits. It is 3-4 percent for a postwar first-generation vehicle, and 11-15 percent for today's vehicles. On the other hand, the relative weight of crew and assault troopers is showing a tendency to decline.

One layout indicator is specific consumption of metal, which is defined as tne ratio of a vehicle's empty weight fueled to number of personnel carried and characterizes the quantity of structural materials required to provide the prescribed level of vehicle performance characteristics.

For armored personnel carriers not carrying special additional armament and equipment, specific consumption of metal with a prescribed level of protection characteristics depends chiefly on vehicle accommodation capacity.

Axle load distribution affects a number of important vehicle performance characteristics (tractive effort and speed, braking, cross-country performance, controllability, stability). Axle load distribution depends primarily on adopted general layout decisions. In order to improve cross-country performance, the front-axle wheels are less heavily loaded than the rear-axle wheels for the majority of vehicles. For two-axle vehicles front-axle loading comprises 42-50 percent of vehicle weight. For three-axle vehicles it is desirable that loading on the front wheels not exceed one third of vehicle combat weight.

In distributing axles along the wheelbase, front axles are usually overloaded. In order to ensure a desirable character of distribution of loads in three-axle vehicles, in many instances the middle axle is shifted forward (axle formula 1-1-1), or the middle axle is even positioned close to the front axle, under the engine and cab (axle formula 2-1). Front-axle loading can range from 21 to 24.5 percent for four-axle vehicles, with 45-49 percent of vehicle combat weight on the front two axles.

Combat weight is one of the principal criteria for evaluating a wheeled combat vehicle. Increasing hull protection is usually limited by the prescribed maximum combat weight. Combat weight exerts considerable influence on tractive force and speed, vehicle cross-country performance and transportability. One of the principal factors limiting the combat weight of a wheeled vehicle is maximum loading on each wheel, which means not allowable loading limited by tire construction but the loading which, with satisfactory wheel size, would ensure ground pressure on the contact area which is close to that of tank tracks.

Considering allowable a wheel diameter of 1.3-1.5 m and ground pressure not exceeding 0.8 kg/cm^2, at the present state of tire engineering, wheel loading should not exceed 2,700-3,000 kg. Consequently, combat weight should not exceed 22-24 tons for a four-axle vehicle with the present state of tire engineering. Another factor limiting maximum vehicle combat weight is buoyancy requirements. Finally, combat weight, alongside dimensions, is limited by demands of air transportability.

Chapter 3. NEW WHEELED VEHICLE DESIGNS

In spite of significant improvement of individual components and systems, foreign experts are of the opinion that one can hardly expect any major qualitative leap forward in the development of wheeled vehicles based on traditional designs, and therefore improvement of wheeled equipment is also continuing in the area of seeking new solutions and elaboration of fundamentally new wheeled vehicle designs.

Taking account of the fact that development of WAV is based on the automotive industry, foreign experts are examining new advances in automotive engineering as possible ways to improve wheeled armored vehicles. Vehicles of an unconventional design which gives them capability to negotiate substantial vertical obstacles include the Metrack and Flextrack vehicles, which were developed in Switzerland.

The principal distinctive feature of the Metrack vehicle is the fact that its front and rear sections are articulated to the middle axle. This enables each part of the vehicle to turn relative to the other by an angle of up to 30 degrees in the vertical plane. Such a design enables the vehicle to negotiate substantial vertical obstacles and permits the vehicle to travel laterally on hillslopes while maintaining the body and cab in a horizontal attitude by lowering the wheels on one side of the vehicle. The vehicle travels with raised middle axle on hard-surface roads. In this configuration the front wheels are steerable. The vehicle has a short turning radius with raised front or rear wheels, by braking one of the wheels on the middle axle. Employment of this principle of turning makes it possible to obtain new vehicle turning performance capability.

A number of other types of articulated combat vehicles have been developed in recent years, consisting of two or several elements. The future potential of articulated arrangements is determined not only by the possibility of improving the agility and cross-country performance of vehicles of this type but also a number of tactical advantages. These advantages include air transportability and rapid return to service of damaged vehicles by maintaining stocks of complete replacement motor and trailer elements. Lockheed (United States), for example, has developed several types of articulated vehicles. These include the Twister four-axle articulated vehicle, on the basis of which both army trucks and WAV have been developed (Figure 3.3.1).

The Twister WAV consists of two-axle all-drive sections, each of which contains its own engine. The forward section employs independent suspension, and the rear section -- bogie suspension. The rear section comprises an armored hull in which the crew is positioned, and the turret carries a 20 mm automatic gun. The vehicle's

combat weight is approximately 9 tons. This vehicle is high-powered and fast. Power-to-weight ratio is more than 50 hp/t. Maximum speed is 105 km/h, and acceleration from zero to 72 km/h takes only 12 seconds. The vehicle possesses excellent cross-country mobility. There also exist amphibious versions of the Twister.

Figure 3.3.1. Twister Articulated Wheeled Armored Vehicle

Alongside examination of wheeled equipment development trends, each of which is based on a solid technical foundation and produces given particular high performance characteristics, we should note that in recent years there have been observed attempts to draw the attention of experts to technical ideas which at times have been of the nature of the fantastic. Such ideas include, for example, proposals to design vehicles with square wheels, walking, jumping vehicles, etc. The large number of new idea proposals attests to the fact that wheeled vehicles are at a stage of intensive growth and development.

SECTION IV. SERVICING AND MAINTENANCE OF ARMORED EQUIPMENT

Chapter 1. SERVICING OF ARMORED EQUIPMENT

The technological revolution has made it possible to reequip tank troops with new combat vehicles. What has happened is not a simple renewal of the fleet of combat vehicles but equipping of the troops with large numbers of new types of combat vehicles, possessing excellent combat performance characteristics.

Maintaining this equipment in a continuous high state of combat readiness is a very complex and critical task. In the process of vehicle operation, their combat and operational performance indices decline for various reasons. Maintaining performance at a high level is achieved by prompt vehicle servicing and maintenance.

Technically knowledgeable vehicle operation, regular routine care and maintenance, prompt correction of noted malfunctions, proper care and safekeeping are the principal factors which ensure a high level of combat readiness for armored equipment. Let us examine these factors in somewhat greater detail.

1. Principal Points of Care and Servicing of Armored Equipment

Organization of care and servicing of armored equipment involves an aggregate of measures performance of which ensures constant combat readiness of subunits, units and combined units. The most important of these include ensuring a high degree of vehicle combat readiness, maintaining vehicle operational reliability at a high level, reducing time expenditures on vehicle servicing, and extending time between overhauls.

Performance of these measures depends first and foremost on the adopted technical servicing system as well as the volume, character and periodicity of vehicle inspection and servicing operations.

The armored equipment servicing system is the organizational foundation which determines and regulates all activities pertaining to vehicle utilization, safeguarding and servicing. The following demands may be imposed on the system of armored equipment servicing:

maintaining at all times a maximum number of armored vehicles on line;

capability of system application without substantial reorganization both in peacetime and in time of war;

securement of maximum simplicity and uniformity of planning, record keeping, reporting and monitoring of all measures specified by the system.

A scheduled preventive vehicle maintenance system meets these requirements most fully. It provides for performance of an aggregate of measures aimed at performing preventive maintenance procedures, prompt detection and correction of problems.

Vehicle servicing and maintenance measures are carried out on the basis of a prior prepared list of mandatory procedures at strictly specified time intervals of vehicle use or storage. The system aims at extending vehicle service life and reducing to a minimum expenditures of time and money on vehicle repairs. It is precisely for this reason that such a system has been adopted in the Soviet Army.

The adopted system has a number of other advantages as well. It provides the following:

continuous information to the command echelons on the technical status of vehicles, since it specifies mandatory vehicle technical inspection in the process of utilization or storage;

decreased repair operations labor requirements, and consequently less time spent by vehicles in the shop, since servicing and maintenance are performed in a scheduled manner, at strictly determined time intervals of vehicle utilization or storage, with correction of spotted defects;

savings in spare parts and materials required in the first-line maintenance of armored equipment, since detection and correction of minor problems in the process of servicing and maintenance eliminates the possibility of these problems becoming more serious, and consequently also eliminates the possibility of damage accumulating;

uniform work loading of maintenance and overhaul facilities in conformity with their designation and production capabilities, since vehicles are taken off line for maintenance on the basis of an evaluation of their technical state, determined in the process of vehicle servicing and maintenance.

Of considerable importance in armored equipment operation and maintenance is classification of types of servicing and maintenance. The classification specifies three categories of inspection and maintenance routines for vehicles in operational service (daily inspection and servicing, servicing and maintenance 1 and 2), and two categories of inspection and maintenance procedures for vehicles in storage (routine and annual). In addition, seasonal servicing procedures are specified for all vehicles, that is, preparation of vehicles for spring-summer or fall-winter operation. The classification also specifies inspections before vehicles leave the depot and en route (during halts).

The servicing and maintenance categories differ from one another not only in extent but also nature of procedures performed. For example, the inspection prior to leaving the vehicle area or depot is for the purpose of determining that vehicles are in proper running order. Daily servicing procedures, in addition to inspection, include topping off fuel and lubricant tanks and, when necessary, performing tightening and adjustment operations. Servicing and maintenance procedures 1 and 2 are performed at specific mileage intervals, specified for each vehicle model.

The purpose of these categories of servicing and maintenance is thorough inspection of the condition of vehicles and correction of noted problems.

Periodicity, extent and sequence of servicing and maintenance procedures, as well as time allotted for performing a given category of servicing and maintenance are specified by equipment operating manuals as well as vehicle servicing and maintenance manuals.

In peacetime a substantial percentage of armored equipment is in storage.

The extent and sequence of procedures performed in readying vehicles for storage as well as maintaining and servicing vehicles in storage are specified by the manual on storage of armored equipment. The extent of routine servicing procedures on vehicles in storage involves, as a rule, checking hull airtightness/watertightness, condition of covers, tarpaulins, ZZK sealing compound, etc. Routine inspection is performed twice a week during equipment servicing hours or vehicle maintenance day. As a rule the vehicle annual inspection involves repeat storing and preservation procedures.

The armies of the principal capitalist countries which are members of the aggressive NATO bloc employ a scheduled preventive maintenance system on combat equipment. Maintenance unit commanders are responsible for performance of combat vehicle inspection, servicing and maintenance procedures.

According to the classification adopted by the majority of NATO member nations, vehicles are subdivided into four groups:

tracked vehicles and wheeled combat vehicles (tanks, armored personnel carriers, tracked prime movers and all vehicles based on the above);

wheeled and half-track vehicles (automobiles, trucks and wheeled amphibians, half-track vehicles, and all vehicles based on the above);

engineer vehicles;

motorcycles.

Four categories of inspection-servicing and maintenance are specified for all vehicle categories: A, B, C, D, as well as inspections before a day's operations and during halts.

Maintenance procedures A (daily) include all procedures involved in readying vehicles for further operation (inspection, topping off fuel and lubricants, correction of any problems spotted).

Maintenance procedures B (weekly). In addition to the procedures performed during the daily inspection, filters are cleaned, tightening and adjustment procedures are performed.

Maintenance procedures C (monthly) are performed every 400 km on tanks and every 1,600 km on wheeled vehicles. These procedures include tightening and adjustment operations, replacement of filters, relubrication of running gear, etc.

Maintenance procedures D (every three months) are performed every 1,200 km on tanks and every 9,600 km on wheeled vehicles. A thorough inspection of the vehicle is made, and all spotted problems are corrected. Servicing procedures include a number of mandatory operations, for the specific vehicle type and model.

All servicing and maintenance procedures are performed by maintenance unit personnel, with the participation of the crews of the vehicles being serviced.

The condition of vehicles prior to servicing and maintenance and the quality of the work performed following servicing and maintenance are usually checked by test-running a vehicle 5-8 km.

2. Reliability of Armored Equipment

The operating condition of armored vehicles is determined taking into consideration an estimate of their reliability. It is a well known fact that reliability, as the most important component of the quality of an item, is characterized by a number of properties, the most important of which are failure-free operation and service life. They determine the possibility and duration of operation of any items, including armored fighting vehicles.

Failure-free operation and service life [or: longevity, durability] are characterized by a number of quantitative indicators, such as probability of failure-free operation, frequency of failures, operation to failure, mean expected service life, etc.

A basic concept in theory of reliability is failure -- an event following the occurrence of which an item can no longer perform its functions normally. Corresponding to the term "failure" (as applied to a combat vehicle) is loss of mobility (partial or total), protection, combat effectiveness of armament, etc.

Failures are subdivided into complex and simple, based on the conditions of correcting them. Complex failures are corrected by specialized maintenance facilities, while simple failures are corrected by crew members.

The occurrence of failures in the process of operation of armored vehicles is governed by certain laws. These laws are revealed in analyzing a large quantity of statistical data, since the probabilities of breakdown of equipment, even under identical operating conditions, differ significantly from one another. In determining reliability of vehicles on the basis of probability of failure, it is advisable to take into consideration the causes of occurrence of failure. Failures are subdivided into the following groups:

failures connected with natural wear and tear (gradual change in the properties of machinery);

failures connected with a sudden change in the properties of machinery.

In the former case failures occur as a consequence of gradual change in the properties of parts (quality of material, nature of linkages, etc) and in the latter -- due to inappropriateness of selected materials, design and process of manufacture of parts, assemblies and components to the conditions of their operation in a vehicle. It is essential to bear in mind that failures of the first and second

groups can be corrected during performance of scheduled maintenance or during forced vehicle halts.

The most dangerous failures for combat vehicles are those which require the vehicle to halt, since they lead to interruption of performance of the assigned mission. Therefore, when estimating the reliability of armored vehicles, one must select a reliability characteristic which would give an idea of vehicle time in combat formations. Probability of failure Q, requiring a vehicle to halt, or its opposite -- probability of failure-free operation P, can be used as such a characteristic.

Probability of failure-free operation is one of the most convenient characteristics, since for its determination one can utilize data obtained in the process of vehicle operation.

Reliability of armored vehicles can also be estimated by a quantity inverse to probability of failure-free operation, that is, probability of failure.

Probability of failure-free operation or probability of failure can be determined and functionally linked with vehicle operation time in relation to the quantities in which vehicle operation time between repairs is measured.

Other characteristics can also be employed to estimate reliability, which are also based on data obtained in the process of equipment operation. Reliability of parts, assemblies, components and vehicles as a whole, for example, can be characterized by miles or hours of operation to failure.

An operation-to-failure figure gives an idea of the duration of equipment operation between failures. In addition to the failure-free operation probability indicators named above, very frequently one employs such statistical indicators as frequency of failures m and intensity of failures λ.

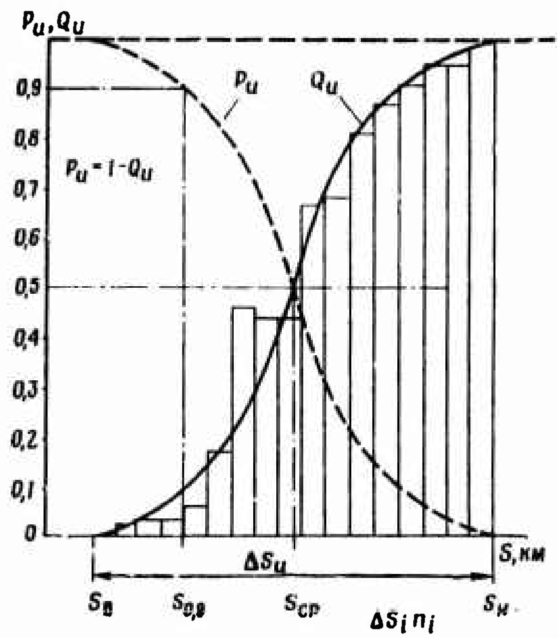


Figure 4.1.1. Characteristics of Longevity of Armored Vehicles:

$P_и$ -- probability of failure-free operation to maximum wear; $Q_и$ -- probability of failure as a consequence of wear; S -- mileage on equipment (km)

The above-indicated armored vehicle reliability characteristics are primarily failure-free operation indicators. For a complete estimate of vehicle reliability it is also necessary to determine longevity indicators on the basis of a study of maximum wear of parts, assemblies, and components.

Mean expected service life S_{cp} and gamma-percent expected service life S_{γ} are longevity indicators. Mean expected service life determines total operating time or mileage corresponding to 50 percent probability that an item will reach maximum or extreme condition of wear.

Gamma-percent expected service life determines total operating time or mileage corresponding to a specified probability of failure-free operation to maximum or terminal wear. Usually gamma-percent expected service life is determined for a value γ=0.80-0.95. A specific quantity is specified taking into account the significance of a component or assembly in a combat vehicle. A smaller value γ corresponds to critical components, and vice versa.

Figure 4.1.1 demonstrates the principle of graphic determination of expected service life on the basis of longevity characteristic curves. As is evident from the figure, quantity S_{cp} has been determined for P_u=0.5.

The above enumerated parameters for estimating the reliability of armored vehicles are utilized in practice not only for the purpose of predicting failures but also for solving problems pertaining to correcting them, since they make it possible to determine the nature of malfunctions and their frequency of occurrence.

In the process of equipment operation, it is necessary to consider the aggregate effect of failures of both types.

Failure-free operation characteristics are more frequently defined by the exponential relationship of indicators λ or m_{cp}, while analogous characteristics for extreme wear are defined by the law of normal distribution (indicators μS -- mean tach hours or mileage to an extreme state, and σs -- root-mean-square deviation of characteristic curve of extreme wear μS).

Table 4.1.1 contains several indicators for a main battle tank.

Table 4.1.1.

1 Наименование агрегата или системы	2 Параметры распределения потока отказов		
	3 отказы внезапные m_{cp}, отказ/тыс. км	4 отказы износовые	
		μS, 10^3 км	σ_s, 10^3 км
5 Коробка передач	0.080	7.246	0.409
6 Главный фрикцион	0.350	6.119	0.257
7 Ходовая часть	1.190	8.095	0.520

Key:
1. Component or system
2. Parameters of distribution of flow of failures
3. Sudden failures m_{cp}, failures per thousand km
4. Wear-caused failures

(Key to Table 4.1.1 on preceding page, cont'd)

5. Gearbox
6. Engine clutch
7. Running gear

As is evident from the figures in the table, the gearbox, and the fan drive in particular, most frequently experiences sudden failures on a main battle tank, while the engine clutch most frequently experiences wear-type failure.

An indicator has been adopted in reliability theory -- failure flow parameter -- to determine the general probability of occurrence both of sudden and wear-type failures. The failure flow parameter is the density of probability of failure of a repair item, determined for a given mileage or tach time. In other words, moments of combat vehicle failures form a flow, called a failure flow. The characteristic curve of this flow is the mathematical expectation of the number of failures for a given mileage. Under conditions of protracted vehicle operation, the mileage of operation figures depends on the occurrence of sudden and gradual failures. In other words, a separate element of a combat vehicle (assembly, unit, system) can break down as a result of the occurrence of even a single failure. In this case the overall probability of failure-free operation is determined by the rule of multiplication of probabilities.

If the overall flow of failures of individual elements (assembly, unit, system) is known, it is not difficult to plot an integral characteristic curve of vehicle reliability. An example of such a characteristic curve is illustrated in Figure 4.1.2.

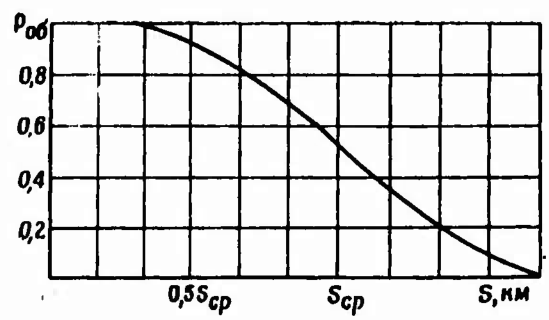


Figure 4.1.2. Integral Characteristic Curve of Armored Vehicle Reliability

Based on an analysis of the characteristic curve of reliability of vehicles or failure flow, one can determine the list and quantity of armored equipment spares to be carried, a list of requisite gear and equipment for repairing vehicles, as well as the composition and output capacity of maintenance units.

No less important reliability indicators for combat equipment are vehicle remontoprigodnost' [repair suitability] and storability or "shelf life."

Repair suitability is a comparatively new term, which is coming into increasingly widespread use. Repair suitability is defined as the properties of an item (vehicle, its components and assemblies) which characterize its suitability for prevention, detection and correction of failures and malfunctions by means of performance of servicing and repair operations.

Mean vehicle repair time can serve as a quantitative indicator of repair suitability. In addition to mean vehicle repair time, one can also utilize for estimating vehicle repair suitability the repair suitability factor, which is the ratio of working time to total down time for repairs. In order to determine the repair suitability factor, one must find working time and then divide this working time by total repair downtime, and obtain the repair suitability factor.

We shall note that the repairability of a vehicle is linked to repair time by a specific relationship. The function of distribution of probability of restoration of a vehicle to service is the integral probability that a malfunctioning vehicle will be returned to an operable condition within a downtime not greater than a specified figure.

The corresponding probability density is called density of repair time probability. Therefore repair time, measured experimentally or obtained by calculation, should necessarily be linked with distribution of probability of restoration to operable condition.

Thus mean time to return vehicles to service can serve as a principal evaluative parameter of vehicle repair suitability. This is not the only possible criterion, but it is the most appropriate for estimating repair suitability, since it can be specified, measured, or calculated. The latter circumstance will also in large measure assist in determining probability of repair and return to service, since from mean return to service time one can easily transition to determination of probability of repair and return to service if the law of probability distribution is known.

In peacetime conditions, also of importance for combat equipment is such a reliability indicator as storability or "shelf life." Storability is defined as the capability of a vehicle to preserve specified performance characteristics during and after a period of storage specified by technical documentation.

For example, mean period of storability, gamma-percent period of storability, etc can serve as storability indicators. Both indicators determine probability of performance of assigned mission by a vehicle following storage. The importance of this indicator is due primarily to the fact that in peacetime conditions a limited number of vehicles are used, while a large percentage of the total are maintained in extended or short-term storage. It is quite obvious that probability of performance of mission following storage is determined in large measure by such a reliability indicator as storability.

In the process of vehicle storage, they are affected by the environment, as a result of which vehicle parts, assemblies and components age and are subjected to corrosion. Gas, atmospheric, and liquid corrosion are the most common causes of damage to the surface of parts, assemblies, and components.

Chemical corrosion occurs in an aggressive medium which does not conduct electric current. In this instance breakdown of metal takes place as a consequence of direct combining with elements in the environment; electrochemical corrosion occurs with contact between metal and a liquid which conducts electric current. In addition to the formation of chemical compounds, there occurs migration of electrons from one region of metal to another. This process, caused by surface breakdown, is

promoted by the presence of impurities in the metal and various contaminants on its surface. The process of corrosion is characterized by rate of occurrence, defined as the ratio of corrosion losses from a unit of metal surface to period of time.

The most important factors which determine rate of atmospheric corrosion are humidity and degree of air contamination with coal dust, fly ash, and especially sulfur dioxide.

Parts are protected against corrosion as follows: by influencing the environment by purification treatment and employment of corrosion inhibitors; by applying protective films to the vulnerable surface (chemically passive, oil, paint, of corrosion-resistant metals); by employing inert gases in vehicle storage; finally, by design measures which ensure the absence of adverse contact between metals and alloys (for example, aluminum with copper or bronze).

The effectiveness of different methods of protecting armored equipment from corrosion is quite varied. The most effective method is airtight sealing, with subsequent dehumidification and employment of inert gases. Less effective are preservation with oils and greases, as well as employment of inhibitors. Combined utilization of oils and greases together with inhibitors, however, produces positive results, providing extended protection from corrosion and shortening demothballing time. Employment of inhibitors in combination with oils and greases is also important because it cuts storage costs, since these items are inexpensive. For example, employment of thickened sodium nitrite solutions, providing extended corrosion protection to ferrous metal parts, proved to be cheaper than employment of petroleum-base protective greases.

We should note that in the NATO bloc member nation armies, a portion of the vehicles of combat units are in base or rear area storage.

Vehicles are prepared for storage by maintenance unit specialists and vehicle crews. Prior to putting into storage, three-month servicing and maintenance procedures are performed. Coolant is drained from the cooling system, and storage batteries are removed from the vehicles. All openings are tightly closed, and the vehicles are covered with a tarpaulin.

Vehicles prepared in this manner can be stored up to 3 months. With longer storage vehicles are hermetically sealed, and special dessicators are placed inside the hull.

3. Combat Readiness of Armored Equipment

A high degree of combat readiness of subunits, units and combined units depends in large measure on organization of combat equipment servicing and maintenance. The organizational forms of utilization, maintenance and storage of combat equipment in turn should take into account the character of today's warfare (operation), as well as the role and place of subunits, units and combined units in accomplishing tactical and operational missions. The combat readiness of tank troops subunits, units and combined units is evaluated first and foremost by the time required for readying armored equipment to perform assigned missions. Time required to put equipment into a state of full combat readiness in turn depends on many factors, the most important of which are the design features of vehicles, and in particular their suitability for operating in various conditions, degree of proficiency of personnel and, finally, organization of work procedures.

Work is particularly complicated in winter. This is due to the fact that at low temperatures much time is expended on installing removed equipment (storage batteries, sights, radio sets) and on preheating the engine for startup.

Therefore while at temperatures above freezing readying vehicles and engine startup are accomplished literally within a few minutes, time required for these procedures may be tens of times greater at subfreezing temperatures.

Figure 4.1.3 shows the labor requirements of procedures involved in readying an engine for startup in winter conditions.

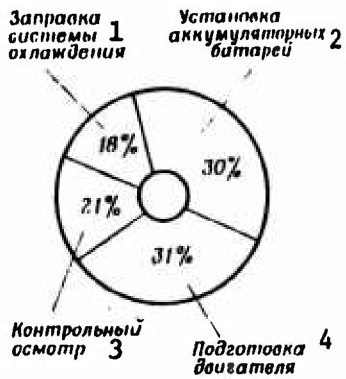


Figure 4.1.3. Labor Requirements in Readying an Engine for Startup in Winter Conditions

Key:

1. Filling cooling system	3. Inspection
2. Installing storage batteries	4. Readying engine

As is evident from the figures in the diagram, the greatest amount of time (more than 60 percent) is expended on installing storage batteries and readying the engine before startup.

In order to fire up the engine successfully, it is necessary to perform a number of measures which provide normal engine operating conditions. First of all it is essential that spontaneous fuel ignition occur in the combustion chamber. This is possible only when the temperature in the combustion chamber at the end of the compression stroke exceeds the fuel spontaneous ignition temperature.

Modern fuels and starting devices make it possible to attain a fuel spontaneous ignition temperature in the combustion chamber at an ambient air temperature of not below -7°C. Consequently, in order to obtain a reliable engine start, it is necessary either to preheat the air entering the cylinders or to employ fuels with low spontaneous ignition temperatures. Such fuels are called starting fluids. Usually these are a mixture of ethers with an ignition temperature 150-200°C lower than that of normal fuels.

Ensuring that oil reaches the crankshaft bearings is no less important. For modern engines with sliding bearings this is possible if oil viscosity is not below 50 St (such a viscosity is reached at 0°C for MT-16p oil). Consequently, in order to ensure normal engine operating conditions it is necessary either to preheat the oil or employ low-viscosity oils.

We shall note that the employment of starting fluids and low-viscosity oils for starting engines in winter conditions is of a limited nature. This is due to the fact that cold engine startup has serious drawbacks. After firing up a cold engine with starter fluids, the engine runs very rough, which has an adverse effect on crankshaft bearings. Warming up the engine is accompanied by considerable corrosive wear on cylinder liners, piston rings, etc. Therefore a second solution has been extensively employed in the practice of design and operation of armored equipment -- preheating air, fuel, engine oil, etc. Air and liquid preheaters are employed to heat fuel and other consumables. Air as a rule is preheated in intake manifolds.

Liquid preheaters are connected into the engine cooling system. Preheating can be applied to cylinder head and engine crankcase, oil in the supply tank and oil line. With liquid preheaters, air entering the combustion chamber is also preheated.

Usually duration of warmup is determined, depending on engine design and preheater output, figuring that liquid warms by 2-3°C in one minute's time. In order to ensure normal engine operating conditions, engine coolant must be heated to 80-100°C.

Incorporation of preheaters on modern combat vehicles has made it possible significantly to reduce time expended on engine startup. Preheaters can be efficiently utilized, however, only when personnel are highly trained and work procedures are thoroughly organized.

For example, a preheater should not be switched on until the engine cooling system is ready and the storage batteries have been installed. Therefore, when organizing preparation of vehicles for operation, it is necessary thoroughly to plan the sequence of performance of work procedures. Thorough knowledge by crew members of their duties pertaining to making vehicles fully combat ready and observance of the requisite sequence of work procedures shortens the time required to ready an engine for startup to that time during which vehicle inspection is being performed.

We should note that considerable attention is being focused on armored equipment operation at low temperatures. Measures include employing low-viscosity oils and Arctic fuels; injection of fuel or special starting fluids into combustion chambers, employment of mobile engine heaters, storage batteries, and employment of heaters for warming combat vehicle crews.

Chapter 2. REPAIR AND OVERHAUL OF ARMORED EQUIPMENT

Modern modes of vehicle utilization, maintenance and storage have raised to a high level sophistication of maintenance of armored equipment. Repair and overhaul of armored vehicles, however, remains the most important condition for ensuring a high level of tank troops combat efficiency. This is due to the fact that armored vehicles fall within a category of combat vehicles which, in the course of performing assigned missions, are operated under maximum performance conditions and under a constant threat of being hit by various weapons.

Maximum-performance operation and hostile fire can lead to large-scale breakdown of armored equipment. Let us examine the causes and forms of manifestation of various malfunctions in combat vehicles.

1. The Combat Vehicle as Object of Repair

Armored vehicles, in contrast to conventional trucks, are more suited to repeated repairs. A strong hull, alongside protective function, ensures normal operation of assemblies, components and mechanisms for an extended period of time.

Practical operational experience with armored vehicles indicate that the presence of a rigid body makes it possible repeatedly to perform all kinds of repairs, ensuring these vehicles a long service life. For example, the T-34 tank -- the main battle tank of the Great Patriotic War period -- averaged in the postwar period four to five major overhauls during its entire service life, retaining excellent combat and operational performance characteristics. This tank's retirement, except for cases of accidents, was determined chiefly by obsolescence, not by a lessening of the original combat and operational performance.

Analysis of the causes of malfunctions in armored vehicles indicates that problems can be subdivided into groups.

The first group includes malfunctions caused by natural wear of parts. The process of wearing out of parts is quite logical. This pattern is manifested in change in the state, dimensions and shapes of working surfaces of parts, causing deterioration of performance of linked machinery couples, assemblies, and mechanisms. Such malfunctions are connected with the length of time a combat vehicle has been in operation.

The second group includes defects caused by manufacturing flaws, design deficiencies, etc. Such defects appear suddenly and lead to unforeseen (random) breakdowns of individual vehicles.

A third group includes defects caused by various emergency situations. This group of malfunctions is not functionally linked with the length of time a combat vehicle has been in operation. Malfunctions caused by emergency situations usually crop up suddenly, independently of a vehicle's length of service. This group of malfunctions includes breakdowns caused by violation of equipment operating regulations, combat damage caused by various hostile weapons, as well as damage connected with bogging down, flooding, collision and overturning of armored vehicles.

Figure 4.2.1 contains a classification of causes of malfunctions in armored vehicles.

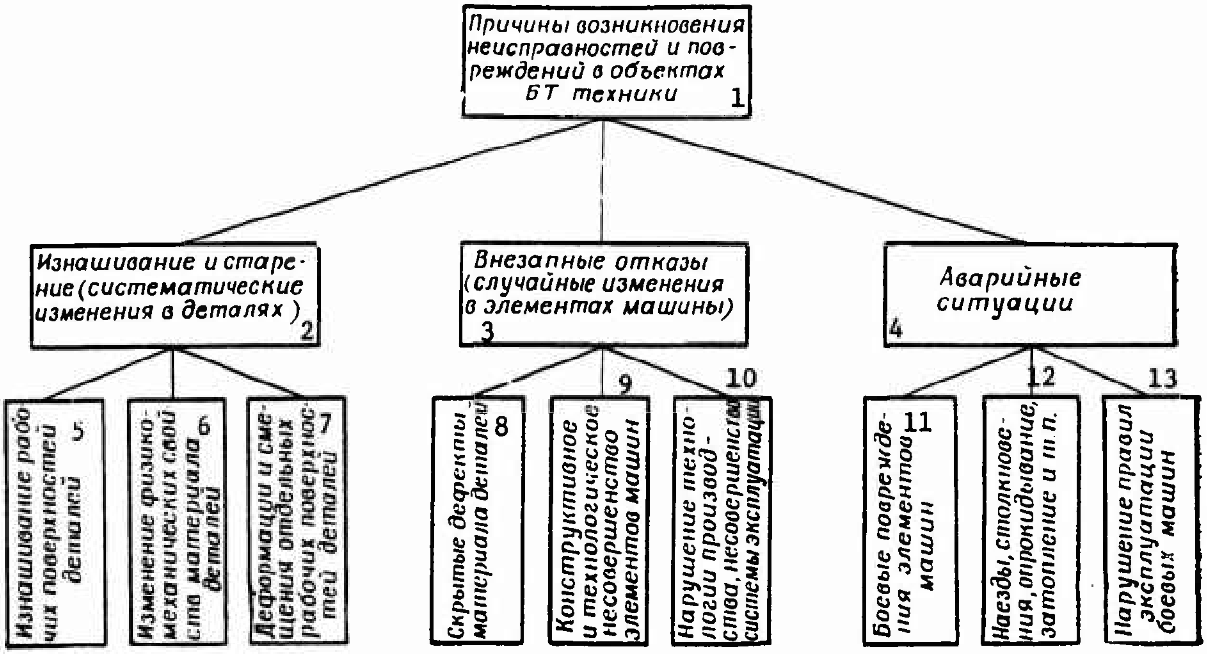


Figure 4.2.1. Classification of Causes of Malfunctions and Damage in Armored Vehicles

Key:
1. Causes of occurrence of malfunctions and damage in armored vehicles
2. Wear and aging (systematic changes in parts)
3. Sudden failures (random changes in vehicle components)
4. Emergency situations
5. Wearing of working surfaces of parts
6. Change in physical and stress-strain properties of material of which parts are manufactured
7. Deformations and displacements of individual working surfaces of parts
8. Latent defects in material of which parts are made
9. Design and manufacturing flaws in vehicle components
10. Failure to adhere to manufacturing process, defect in system of operation and maintenance
11. Combat damage to vehicle components
12. Accidents, collisions, overturning, flooding, etc
13. Violation of combat vehicle operation regulations

Each of these causes affects the possibility of occurrence of a defect and its character, as well as the mechanism of its occurrence.

The magnitude and character of natural wear of parts depend on amount of friction and the environment (coolant, grease, fuel, gases), as well as conditions of vehicle operation or storage. In peacetime natural wear of parts is the principal cause of malfunctions in vehicles. As a result of wear of working surfaces, gaps increase in moving connections between parts and their mutual position changes, which disrupts normal operating conditions of assemblies, mechanisms, and systems.

Change in the size and shape of parts leads to redistribution of effective loads and to an increase in contact stresses, as a result of which processes of wear accelerate. With a significant increase in gaps between parts, parts can break down as a consequence of dynamic loads. For example, wear on the working surfaces of crankshaft-sliding bearing contact can cause an engine to break down from a bearing seizing. Road wheel support arm bushing wear in a tank suspension leads to excessive increase in road wheel camber and, as a consequence, to premature road wheel failure.

Part deformations occur chiefly as a result of the dynamic effect of forces. But they can also be caused by processes of aging of parts, by fatigue phenomena, fluctuations in operating temperatures, etc. For example, deformation of the hull floor in some tanks causes displacement of base and mounting surfaces under the main components of the engine-transmission group. Relative displacement of components leads to intensive wear on couplings, to significant overloads on the bearings of interconnected shafts, etc. All this in the final analysis shortens equipment life and leads to equipment breakdowns. In the course of vehicle operation there can also occur such defects as formation of gum and carbon deposits on part surfaces, damage to electroplating and paint coatings, aging of rubber and plastic items, etc.

In addition to failures and malfunctions occurring as a result of gradual change in the properties of parts, contacts and linkages, sudden failures are possible, the occurrence of which is not functionally linked with how much mileage the vehicle has logged. Such failures are caused by latent defects (cracks, cavities), by faulty manufacturing, etc.

The combined effect of the above-noted defects leads to worsening of vehicle operation and combat performance characteristics.

Accidental damage to parts and assemblies occurs as a consequence of design or manufacturing flaws, violation of operating or maintenance rules, as well as poor quality of repair. Under conditions of wartime, the most common cause of malfunctions in vehicles will be the effect of various weapons. This can result in deformation of parts, assemblies, and components caused by the shock wave from a nuclear burst; failure of armored hulls and damaged components, assemblies and parts in the hull interior as a result of blast effect and shaped-charge projectiles; vehicle burning and, as a consequence, change in the structure of the material of which parts are made, caused by luminous radiation from a nuclear burst or incendiary weapons.

Alongside this, in wartime conditions, as well as during peacetime combat training, some vehicles are put out of commission due to bogging down, collisions, overturning, etc.

The nature of malfunctions due to these causes can be quite diversified. For example, as a result of collisions or overturning of vehicles there occurs deformation of parts, assemblies and components, external equipment is damaged (tanks, racks, mud guards), gun laying and stabilization systems are put out of commission, etc.

Flooding and bogging down can result in malfunctions in weapons, optics and special electrical and radio gear units, devices and mechanisms due to damage to paint coatings, rubber items, etc.

Malfunctions can also occur in engine fuel, lubrication and compressed-air starter systems caused by entry of water, sand, and dirt.

Also possible in time of war are malfunctions characteristic of peacetime vehicle operation. In fact, they can form in parts, assemblies and components even more rapidly, since under conditions of combat operations vehicles operate at maximum performance and on rough terrain.

Thus various damage and failures can occur in vehicles. As a consequence of this, such vehicles require maintenance and repair, with a varying amount of labor outlays and repair operations to return vehicles to service.

A numerical estimate of the possibility of occurrence of damage and failures in vehicles is a probability quantity and as a rule is connected with a specified, fixed time interval or mileage figure.

2. Production Process and Technology of Repairing and Overhauling Armored Fighting Vehicles

An increase in the variety of armored vehicles and an increasing number of armored vehicles employed in the Armed Forces impose new and greater demands on organization of vehicle repair and overhaul. Repair and overhaul of combat vehicles are handled within a unified system, which encompasses maintenance facilities of all echelons.

The specific features of employment of armored vehicles dictate a number of basic features of tank repair and overhaul in comparison with organization of maintenance of other types of combat equipment. These features consist in the following:

1. Repair and overhaul of damaged armored equipment is differentiated in conformity with the distribution of duties among maintenance facilities of all echelons. This distribution is caused, in the first place, by a substantial fluctuation in the operating condition of combat vehicles requiring maintenance, and in the second place, by the necessity of repairing these vehicles as quickly as possible and in the immediate vicinity of troop dispositions.

2. Differing conditions of performance of repair (permanent facility and field repairs, at a central maintenance facility or at the spot where vehicles break down) require differing methods of organization of production.

3. The majority of damaged vehicles are repaired by mobile maintenance facilities under field conditions, strictly differentiated in relation to the designation of the maintenance facility.

The above enumerated features require that vehicle repairs be organized taking into account the specific features of the missions assigned a given maintenance subunit or unit. Tank repair activities are usually organized within the framework of a maintenance facilities group, united by similar particular missions. For example, vehicle major overhauls are performed within the system of fixed-location or mobile overhaul enterprises, while performance of scheduled medium overhauls is performed within the system of facilities of combined units and formations, etc.

The term "repair production" is usually concretized when applied to an individual maintenance facility. The production process is organized in the maintenance facility, a process which includes to one degree or another the above-stated components of repair production.

The production process of repair constitutes an aggregate of measures and actions as a result of which a damaged vehicle, which has been brought to the maintenance facility, is restored to a specified level of performance condition, determined by the repair specifications. The production process is organized taking account of the specific features of repair of combat vehicles of various types and models, as well as the conditions prevailing at a given maintenance facility.

In addition to the conventional division of repairs according to the categories adopted in the civilian economy (minor repairs, medium overhaul, major overhaul), the conditions of operation of maintenance facilities are taken into consideration in elaboration of the production process of armored vehicle repair. For example, assembly-line organization of production is characteristic of major overhaul of vehicles and vehicle components, with relatively stable labor requirements, qualification requirements and number of personnel, a quota-set work day, as well as a large production schedule. Characteristic of minor and medium reapirs, performed by unit maintenance facilities, is the "dead-end" mode of organization of repair of vehicles and vehicle components.

The combat vehicle repair production process is organized taking account of demarcation of functions between maintenance facilities by work volume and operations list. It usually includes the following measures:

preparation, planning and production management;

preparation and operation of means of production (test benches, machine tool equipment, tools and accessories);

support of production with maintenance facilities, spare parts and materials, all types of energy, as well as engineering drawings and repair manuals;

all operations to repair damage directly on a combat vehicle (component), as well as inspection of completed repairs for quality, testing and release of the repaired vehicle.

That part of the production process which is determined by volume, sequence and content of work pertaining to the immediate repair of damage and correction of malfunctions in the components, assemblies and parts of a combat vehicle is called

technological process of repair. It is the most important component part of the production process of armored equipment repair. Practical implementation of the technological process exerts considerable influence on the entire production process of returning combat vehicles to service, including organizational matters, and all measures pertaining to support of maintenance facility production activities.

Effectiveness of the technological process of vehicle repair is evaluated on three criteria:

quality of repaired vehicles;

productivity of repairs;

economy of the repair process.

The quality and productivity indicators are the principal indices for combat equipment.

The quality of combat vehicle repair is determined by the aggregate of performance characteristics restored in the process of repair and determining a vehicle's suitability for subsequent combat utilization. Figure 4.2.2 presents in the form of a diagram the principal indicators most frequently used to evaluate the quality of repair on armored equipment.

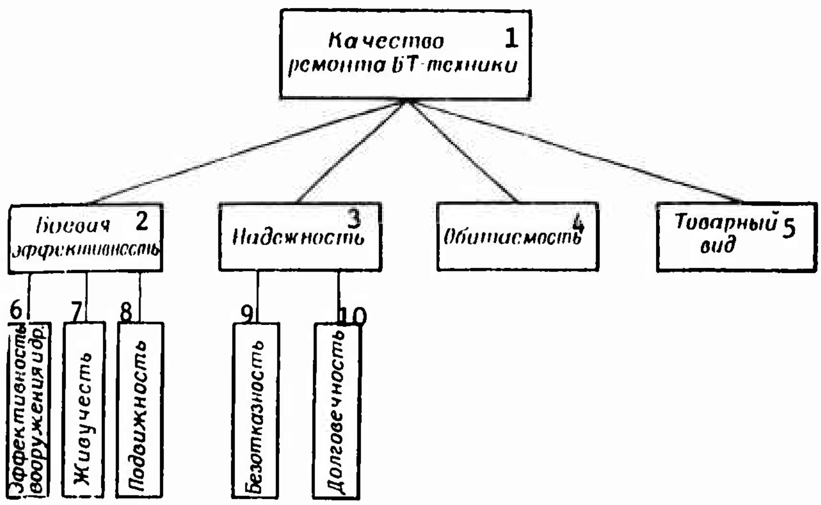


Figure 4.2.2. Block Diagram of Repair Quality Evaluation Indicators

Key:

1. Quality of repair of armored equipment
2. Combat effectiveness
3. Reliability
4. Habitability
5. Appearance
6. Effectiveness of armament, etc
7. Survivability
8. Mobility
9. Failure-free operation
10. Longevity

As is evident from the diagram, performed repairs should first and foremost ensure restoration of the performance characteristics of a vehicle to a specified level. These indicators include the parameters of mobility, weapons effectiveness, degree of protection, etc. The entire aggregate of these indices determines a vehicle's combat effectiveness. In addition to this, operations should also be performed which restore reliability indices and give the vehicle a good physical appearance.

3. Armored Fighting Vehicle Maintenance Facilities

An important condition for maintaining troop combat efficiency at a high level is prompt and quality repair of damaged vehicles, which is secured by the following measures:

continuous vehicle inspection and prompt vehicle designation for maintenance;

availability of well equipped maintenance subunits and units and continuous preparedness of these units to perform vehicle repair activities;

prompt determination of locations where vehicles have broken down and rapid response by maintenance facilities;

high level of maintenance skills and field proficiency on the part of maintenance personnel;

continuous maintenance of equipment, tools and accessories in good working order in maintenance subunits;

correct organization of maintenance operations, observance of the technological process of repair of parts, assemblies, components and entire vehicles;

prompt supply to maintenance facilities of armored and other types of equipment;

close cooperation between maintenance and recovery subunits and units.

As is evident from the above list of measures, in order to maintain the combat readiness of units and subunits at a high level, front-line maintenance facilities repair damaged equipment and assist vehicle crews in performing servicing and maintenance procedures.

Consequently, the availability of maintenance subunits and units which are well furnished with equipment and skilled personnel constitutes one of the decisive factors which ensure a high level of troop combat readiness.

The system of maintenance facilities established in the tank troops includes armored equipment servicing facilities as well as repair facilities. Armored equipment servicing facilities include primarily subunit (battalion) facilities, which are the initial element in the system of organization of first-line maintenance and are designated to perform the following tasks:

participation (jointly with crews) in performing all kinds of servicing operations on battalion tanks;

organization of maintenance pool technical reconnaissance service (accompanying combat formations, spotting and communicating information on locations and nature of damage to disabled combat equipment);

lending assistance to crews of damaged vehicles by correcting minor malfunctions or supplying needed spare parts.

In addition, they are assigned the job of recovering vehicles from the battlefield and removing them to shelters and disabled vehicle collecting points (SPPM), as well as performance of minor repairs on damaged vehicles.

Maintenance facilities of combined units specialize in performing minor and medium repairs on vehicles and as a rule are not enlisted to service armored equipment. In the process of performing their assigned missions, they recover damaged combat vehicles and withdraw them to combined unit SPPM, and restore them to service with minor and medium repairs. Vehicles not to be repaired by first-line maintenance facilities are handed over to higher agencies at the locations where they break down and at unit and combined unit SPPM.

Armored equipment maintenance facilities come within the T/O of tank subunits, units, and combined units and continuously accompany them in the course of combat operations. Organizationally they can be arranged as follows:

in a tank subunit -- as a maintenance section (OTO);

in a tank (motorized rifle) unit -- as a maintenance company (RR);

in a tank (motorized rifle) combined unit -- as an independent maintenance battalion (ORVB).

The organizational structure of maintenance facilities of units and combined units allows for repairing vehicles both at SPPM, at locations where vehicles break down, and in nearby cover. All vehicles repaired by these facilities are returned, following repairs, directly to their subunits and units.

The level of organization of the production process and repair technology at a given maintenance facility is characterized by the sophistication of equipment of the maintenance facility.

A special system of mobile tank maintenance shops has been established in conformity with the volume and character of the work performed in minor and medium repairs on armored equipment. The following form the nucleus of this system:

mobile tank maintenance shop (TRM-A);

mobile electric and gas welding shop (EGSM);

special electrical and radio equipment maintenance shop (MERO);

mobile field maintenance and battery charging station (PRZS).

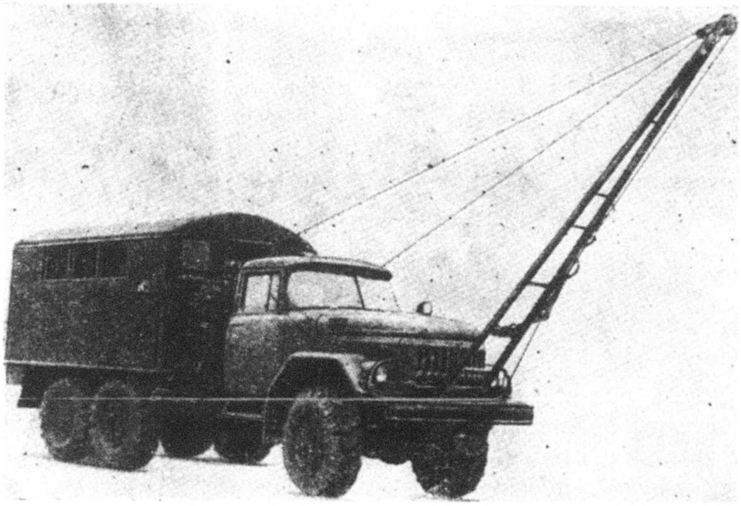


Figure 4.2.3. TRM-A-70 Mobile Tank Maintenance Shop

A technical maintenance vehicle (MTO) has been adopted in the table of equipment for armored vehicle servicing and maintenance.

As is evident from the above list, mobile tank maintenance shops are job-specialized. As a rule they are outfitted with series-produced equipment which is widely used in the civilian economy. Mobile tank maintenance shops are mounted on the ZIL-131 truck chassis and housed in a KM-157 all-metal body. The chassis and basic shop equipment (machine tools, generator units, etc) are highly durable and have a long service life.

Figure 4.2.3 shows a TRM-A-70 mobile tank maintenance shop. All the principal types of repairs connected with natural wear or other causes can be performed with this shop's gear and equipment. The shop is also outfitted with requisite equipment and gear for servicing vehicles after repairs have been accomplished.

Slewing derrick cranes mounted on a truck and tank chassis are employed as hoist devices in performing tank field repairs. These cranes have a lifting capacity ranging from 3 to 12 tons.

Figure 4.2.4 shows an SPK-12G fully-rotating derrick crane mounted on a tank chassis, deployed for operation.

This crane has a 12-ton lifting capacity. It can replace any unit or component on armored vehicles under field conditions.

We should note that mobile tank maintenance shops and cranes are assigned to the line unit on a uniformly equipped basis. This makes it possible to utilize them both at the tactical and operational echelon.

In the NATO bloc member nations the logistical support system includes rear services troops and medical corps troops. Rear services troops in turn consist of maintenance troops, transport and supply troops. Following are the principal missions of rear services troops:

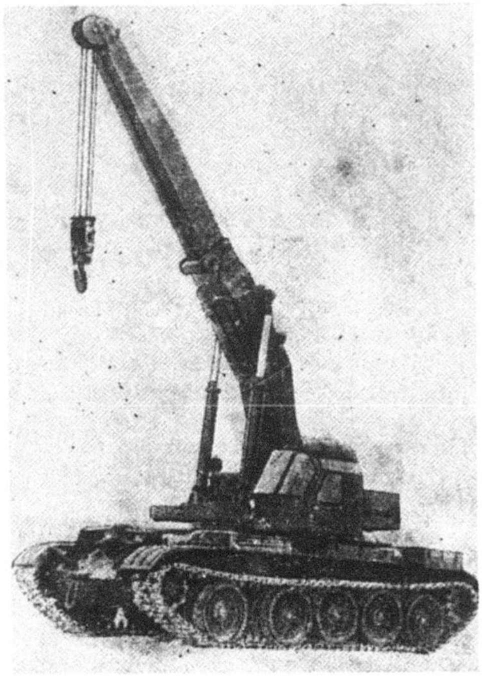


Figure 4.2.4. SPK-12G Fully-Rotating Derrick Crane, Deployed for Operation

maintenance and repair of weapons and equipment;

supplying ammunition, fuel, lubricants, spare parts and all types of technical stores;

supplying food, clothing and other military supply items.

Motor transport and supply troops play a substantial role in organization of rear services activities. Maintenance troops play a no less important role. They have the job of keeping equipment in proper working order, with the aim of ensuring maximum service life and continuous equipment readiness to perform combat missions.

The term "maintaining equipment in proper working order" encompasses care, maintenance, recovery, repair and upgrading of combat equipment. All work pertaining to keeping equipment in proper working order is subdivided into categories and degrees.

Three categories of repairs have been established, depending on the nature and volume of repair activities: first-line maintenance and repairs, field repairs, and base repairs.

In the army of the FRG, base repairs are called factory repairs. First-line servicing and maintenance in the U.S. Army are performed by tank company maintenance sections and tank battalion maintenance platoons, which are equipped with maintenance and recovery vehicles based on organic tank chassis, trucks, and general-purpose vehicles. Damaged vehicles are repaired at the locations where they have broken down and in nearby cover.

Figure 1.1.6. Sheridan Tank (United States)

While not denying the expediency of employing guided missile weapons on tanks, the Americans are presently devoting principal attention to development of guns as main armament.

Armor and special protection. Today the defense has become densely saturated with various both close-range and long-range antitank weapons. In addition, the effectiveness of antitank weapons has substantially increased due to an increased accuracy of fire and greater force of projectile effect on the target. Fixed-wing aircraft and helicopter gunships are being utilized to an ever increasing extent against tanks.

Success achieved in the development of armor defeating weapons, and particularly antitank guided missiles, has resulted in the following: in the foreign press, especially since the Arab-Israeli war in October 1973, has frequently raised the question of the advisability of radically reducing tank armor protection which, in the opinion of the authors of such a plan, would be fully compensated by giving the tank greater mobility, and hence less vulnerability on the battlefield. Other experts, however, are of the opinion that there never have existed any tanks with unpierceable armor. There have always been on the battlefield means of killing tanks with fire. But the thicker a tank's armor, the fewer the weapons which can defeat a tank. Heavy armor substantially reduces the probability of tank kills by fire from various antitank weapons which may be employed on the battlefield, including tank guns. Thick armor places tanks in more favorable conditions in a fire fight with poorly armored enemy tanks, since in such an engagement decisive significance is assumed by the combination of firepower and armor protection.

The fact that armor is one of the most reliable means of protecting a tank's crew and internal equipment from the destructive and casualty-producing factors of a nuclear burst has also in the postwar years been considered an important

vehicle has a top speed of 62 km/h. Figure 4.2.6 shows the Standard armored recovery vehicle in working position.

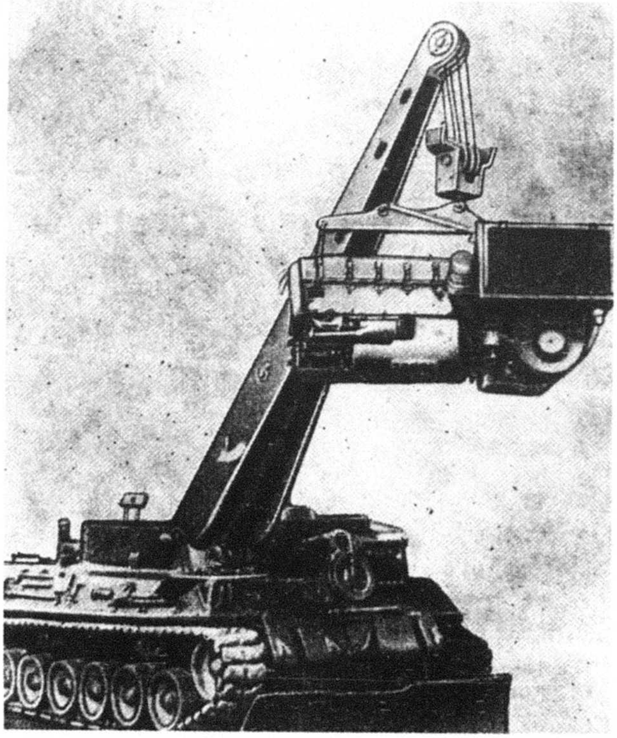


Figure 4.2.6. Standard Armored Recovery Vehicle (FRG) in Working Position

Maintenance subunits and units also have armored equipment maintenance shops. The U.S. Army, for example, is equipped with the M-109 general-purpose shop, the army of the FRG is equipped with the Unimog general-purpose shop, etc.

Multi-axle trailers for transporting tanks and other armored vehicles long distances are extensively employed by maintenance subunits and units.

The availability of a large quantity of diversified armored vehicle repair equipment enables maintenance subunits and units to repair armored equipment both at consolidated maintenance facilities as well as at the locations where vehicles are disabled and behind nearby cover.

Chapter 3. ERGONOMICS IN TANK TROOPS

The development of new weaponry and the rapid evolution of traditional armament, especially tanks, have greatly altered concepts on man's role in armored vehicle operation and control systems. It is impossible today to build tank troops equipment, to organize personnel combat training, and to elaborate theory and practical recommendations on the combat employment of tank units and combined units in the battle and operation without taking into consideration man's potential and capabilities.

Crew-tank systems (CTS) comprise the basis of tank units and combined units. Ensuring optimal functioning of these systems is a most important condition for achieving a high level of tank troops combat efficiency.

The CTS possesses the potential and achieved level of combat effectiveness. The potential level of CTS combat effectiveness (W_p) is a calculated quantity, determined under the condition that in the process of combat operations crews fully utilize the technical potential of their tank. In practice, however, as a consequence of incomplete consideration of man's potential and capabilities in designing and building tanks and non-optimal crew actions in the process of combat employment of tanks, the achieved level of CTS combat effectiveness (W_a) practically always differs from the calculated figure. The ratio of achieved level of CTS combat effectiveness to potential level characterizes the ergonomicity of CTS:

$$H_t = \frac{W_a}{W_p}.$$

The system ergonomicity indicator, which is a function of time, enables one quantitatively to determine CTS combat effectiveness reserve, which can be achieved by means of fuller consideration of the potential and capabilities of crew members and by boosting the level of their training and proficiency.

The achieved level of CTS combat effectiveness is brought closer to the potential level by optimizing the dynamic interaction between crews and tanks and comprises the basis of ergonomic support of efficient utilization by personnel of the performance characteristics of their tanks. Alongside tank firepower, armor protection and mobility, securement of optimal dynamic interaction between crews and tanks has become an inseparable part of the problem of improving the combat efficiency of tank troops.

This interaction is achieved by taking into account ergonomic factors in designing and building armored vehicles, by performing psychological aptitude testing of

personnel in the tank area of specialization, by more efficient tanker training, and by optimizing conditions of combat activities of tank troops personnel.

Designing and building tanks taking ergonomic factors into account includes designing and laying out work stations in conformity with man's physical, physiological and psychological capabilities and the duties performed by crew members. This category of tasks includes ensuring a specific working environment in manned compartments, high-quality mastery of tank equipment by crew members on the specified timetable, as well as requisite conditions for tank servicing and maintenance.

A crew member's work station includes information and motor fields, as well as a seat. Working spaces are designated in the tank hull and turret for positioning personnel, work station elements and for crew member performance of their work activities.

Information field is the name given to that part of the work station where means of information display are placed. The information field includes the instruments and indicators with the aid of which the crew obtains information of the environment, terrain and targets on the battlefield, the position of one's own and adjacent tanks (external information), as well as on the status of equipment, and conditions of vital activity in the tank's manned compartments (internal information).

In organizing an information field, one takes into consideration the most important characteristic of man's organs of sight and hearing, the dimensions of man's field of view, resolving power of the eyes, their sensitivity to color, and the specific features of man's sense of touch, as well as his ability to perceive and analyze sounds. The information field is formed with consideration of providing the simplest dynamics for shifting gaze along the shortest routes and simplification of sensorimotor coordination of movements of controls in response to a received signal.

Motor field is the name given to that part of the work station where controls are located. The motor field includes levers, handles, pedals, pushbuttons, and switches. Lever (handle) turning rates, limits and directions of lever and handle movement, as well as required pull and push efforts are determined in conformity with the anthropometric indicators and psychophysiological characteristics of the crew members. Convenience and ease of control within the zone of principal movements in a standing and moving tank are considered to be the principal requirements on design and layout of individual elements and the entire work field. The link between the information and motor fields should be in conformity with the psychological structure of combat activities and the habits and skills of the person seated at the station and performing his duties under normal, extreme and ultra-extreme conditions.*

The seat provides a solid support for the crew member's body and supports it in an appropriate posture. The size and configuration of the seat and its back, as well

*Extreme stress involves conditions requiring mobilization of the system's "buffer" reserves, while ultra-extreme stress involves conditions requiring mobilization of the "emergency" reserves of the human organism.

as its layout are selected in conformity with man's anthropometric indices.

The working spaces designated for positioning and combat activities of crew members and placement of work field elements, as well as their layout are determined so as to ensure reliable and safe tank crew member activities under the effect of conventional and nuclear weapons, optimal conditions for receiving information (especially external visual information) and for controlling tank components and systems, as well as the possibility of crew member interchangeability without getting out of the tank, assisting and evacuating wounded.

Organization of work stations calls for full consideration of crew member capabilities. A working environment in manned compartments is created on the basis of providing the requisite conditions for tank crew combat activities while remaining on board for extended periods of time with closed hatches.

Degree of mastery and time required to master tank equipment by tank crews are determined by the number of elements of the information and motor fields, frequency of dealing with them, quantity, complexity and duration of operations performed while controlling tank armament and movement, as well as conformity between the characteristics of tank control systems and a person's skills, and level of standardization of crew work stations in regard to military vehicles and equipment used in the civilian economy.

The purpose of psychological aptitude testing is to identify those persons who on the basis of psychophysiological capabilities are suited for training in armored military occupational specialties and subsequent performance of tank fire control and maneuver tasks.

It is a well known fact that people possess differing psychophysiological characteristics. Change in these characteristics with time and under the influence of various factors also varies. In addition, different requirements are imposed on tankers of different occupational specialties. It is possible to determine those persons who possess qualities essential for tankers and consequently to predict in some measure their successful performance by conducting psychological aptitude testing on candidates for service in the tank troops.

M. V. Frunze pointed to the necessity of assigning personnel to military occupational specialties on the basis of their psychophysiological characteristics: "If we send to the navy, to special technical troops and to aviation personnel who are unsuited by physical structure and psychology for service in these arms, we shall be doing great detriment to their combat power."*

Experience indicates that employment of scientific, proven methods of psychophysiological selection based on aptitude testing makes it possible, with a reliability of 76-80 percent, correctly to evaluate people's abilities to master various military occupational specialties. Psychophysiological selection makes it possible to reduce severalfold the so-called failure rate in the operator specialties, to reduce the rate of damage and breakdown of certain technical systems

* M. V. Frunze, "Izbrannyye proizvedeniya" [Selected Writings], Moscow, Voyenizdat, 1977, page 401.

through the fault of operator personnel, to increase the operational reliability of control systems, and to lessen the cost of training personnel.

Considerable attention is devoted to psychophysiological aptitude testing and selection for military occupational specialties in the armies of a number of capitalist countries as well. The U.S. Army came to the conclusion that taking into consideration the psychophysiological characteristics of candidates when selecting personnel for assignment to training centers, especially tanker training, makes it possible to cut approximately in half the total number of personnel washing out for reasons of unsuitability.

Psychophysiological aptitude selection for tank occupational specialties employs analytical and synthetic methods. Analytical method makes it possible to evaluate a person's abilities by determining his psychological qualities requisite for mastering the tanker occupational specialty and effective performance of his duties following training. Occupational aptitude selection by the analytical method is performed with the aid of fill-in questionnaire or apparatus methods.

The essence of the synthetic method consists in determining the occupational abilities of an individual directly on simulators or other technical devices for training personnel. Considerable time is expended on performing studies with this method, and a large number of testing personnel are required. In spite of the complexity of this method, however, data obtained from the conduct of aptitude testing with the employment of personnel training and simulation equipment make it possible most fully to evaluate a person's capability successfully to master tank occupational specialties and to predict the effectiveness of his performance in combat.

Improving the efficiency of tanker training calls for development of a training program in conformity with the psychological structure of tank crew combat activities, seeking ways and means of activating the training process, as well as designing and building crew training equipment.

Training tank crews constitutes a teaching and drilling process as a result of which tankers acquire knowledge, skills and abilities enabling them to perform their duties in a complex combat situation and under extreme and ultra-extreme conditions.

The tanker training system is based on the demands imposed on them by the character, conditions and duration of performance of combat missions by tank troops. Training techniques and methods are developed taking into account the laws of and patterns governing psychophysiological processes and the principles of education science. The task of training includes tank personnel acquisition of knowledge which ensures skilled overall performance, as well as fast and reliable performance of various actions. Training drills promote the transformation of these actions into habits.

Tankers perform their duties within an enclosed space, as a rule interacting not directly with the equipment and tank as a whole but with an information model of their equipment. As a consequence of this, their thought processes are mediated. Therefore in the course of training activities it is essential to form in tankers mediated thinking, to increase their volume of knowledge, to systematize and raise their dynamic level, to reinforce in their memory appropriate skills and habits and

to develop concepts, so that they can quickly evaluate a situation and make a substantiated decision.

One important way to accomplish this task and consequently to shorten the time required for tankers to assimilate specific knowledge and convert it into skills and habits is employment of technical training devices (TTD).

Technical devices used for tanker training are of two types: operator, and games. Operator TTD are for training drivers, gunners, tank commanders and crew, while games TTD are used for training subunit and unit commanders, staff officers, etc.

The TTD system includes training simulators, simulators of phenomena accompanying combat actions, teaching machines, training stands, models, etc.

Technical training devices make it possible to reproduce information models corresponding to the algorithm of tanker combat activity and to exercise objective monitoring and analysis of the learning and training process.

Simulators and teaching machines as a rule present in dosed amounts the conditions of controlling tank direction and speed, operating tank principal and auxiliary armament, as well as the tank as a whole, in conformity with assimilation of training material and training stage by stage. A TTD training information model (TIM) most frequently is controlled (manually or automatically) and makes it possible to change the volume and sequence of presentation of information, and the degree of complexity of execution of individual operations and algorithms. In addition, control of TIM provides transition from one problem to another in the training process and isolation of individual operations from the general algorithm of tanker combat activity, for better mastery of these operations.

Objective monitoring of trainees is accomplished with the aid of special devices which record indicators which enable one to judge the level of and progress in tanker training. Selection of indicators and informative operations is based on ergonomic analysis of the combat activity algorithm of each armor specialist in principal types of combat. The structural arrangement of a TTD is worked out taking into account training of specific armor specialists according to the criteria of processing of information by these personnel in the process of performing their job duties.

In the general case the structural arrangement of a TTD includes means of reproducing the information model, work stations for trainees and instructor, equipment for automated monitoring and analysis of trainee performance, as well as training process control loops. Depending on the purpose of a TTD, their structural arrangements can include a first, second, and third control loops. The circuits along which information on quality of performance of operations by the trainees passes comprise the first training process control loop.

The second control loop is for the purpose of informing trainee and instructor about errors. It includes devices to record, monitor and analyze errors as well as means of immediate display to the trainee. The instructor can control the training process, indicating typical errors and means of correcting them, as well as adjusting the exercises in conformity with their complexity and trainee performance results. A second control loop is incorporated in TTD designed primarily for training tankers who do not possess the requisite knowledge and experience in operating

tank armament and running tanks. TTD with a first and second control loops are used to train operator-specialization tankers.

A third control loop is incorporated in games TTD. It is used for transmitting information from an operator, whose job is to feed into the simulating device traditional signals which disrupt the system. Parrying these signals results in acquiring skills in developing the most efficient system control actions (Figure 4.3.1).

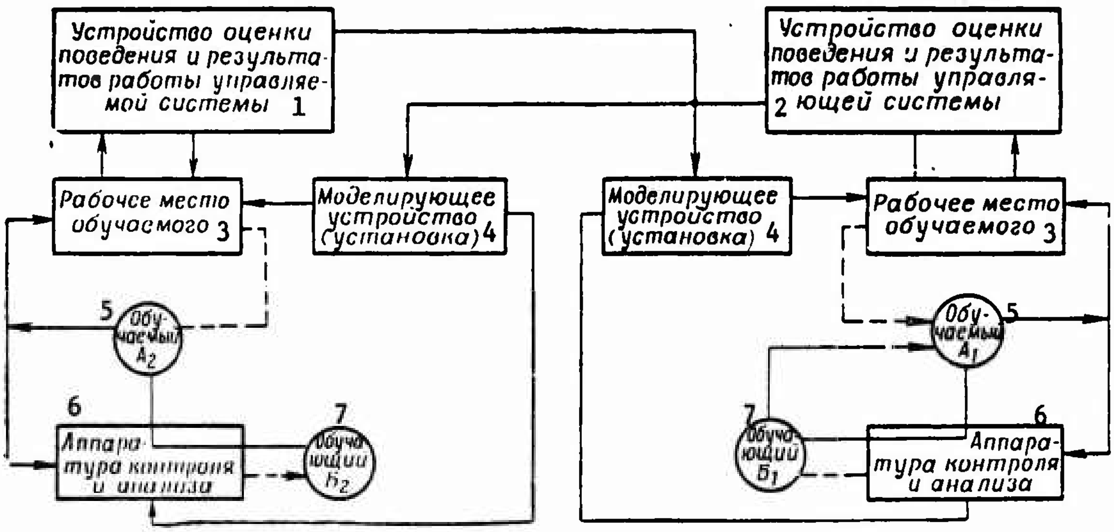


Figure 4.3.1. Generalized Standard Block Diagram of a Games TTD

Key:
1. Controlled system performance and behavior evaluation device
2. Controlling system performance and behavior evaluation device
3. Trainee work station
4. Simulating device (equipment)
5. Trainee
6. Monitoring and analysis equipment
7. Instructor

With the aid of TTD one can simulate individual operations and the entire tank armament and movement control process, which makes it possible to reproduce images maximally approximating those which actually exist in combat. Tankers develop stable attention, perception and memory, as well as sensitivity and capability of analysors to perceive signals, precise and rapid response to signals by a person's sensorimotor sphere, as well as coordination and stability of one's movements in response to incoming signals. The mental model of tanker activities formed with the employment of TTD is sharply reflected in a person's brain and retains its stability under the influence of the negative stimuli which continuously accompany combat operations.

TTD are also widely used to reproduce a physical model of combat. They are employed to simulate phenomena accompanying combat, and "killed" targets are put out of commission without detriment to personnel and equipment. With the aid of a laser kill simulator, for example, one can knock tanks out of action by fire from position, from brief halt, and while moving. The phenomena accompanying firing (flame, bang

and smoke) can be reproduced by firing blank rounds or by employing special devices.

Employment of a laser kill simulator provides feedback between the speed and accuracy of tanker actions and their results. Utilizing this means, one can simulate opposition fire. All this promotes intensification of tanker training. They endeavor to execute fire and tank maneuver faster and more intelligently, make better use of terrain for tank movement, cover and concealment, and choose the most effective modes of fire under given conditions.

Effectiveness of employment of TTD is assessed by how long it takes to form mental models of tanker activities, by capability to perform one's duties in a short period of time, as well as securement of high reliability of personnel functioning under conditions of vigorous hostile countermeasures.

Employment of TTD not only makes it possible to improve the quality of tanker training but is also economically advantageous. Tank crews trained with the employment of TTD which fairly fully simulate the information they require in practical activities implement the potential capabilities of TTD with better performance results. Crew members do a better job of utilizing tank combat performance characteristics, there is an improvement in completeness and quality of perception of information, and a substantial reduction in crew training time.

Optimization of conditions of tanker combat activities consists in selecting and implementing specific pace and duration of tanker activity, as well as in alternating "work-rest" cycles in conformity with human biorhythms and the tasks performed by tank crews. Combat experience and the practical experience of field exercises indicate that effectiveness of crew member utilization of tank combat performance characteristics varies over the course of a 24-hour period and in relation to the duration of performance of combat missions. At night and after two or three march segments in the process of executing a march, the number of tanker errors increases, which leads to a decrease in tank average speed and to decreased distance covered during a march segment.

Man's life occurs in cycles. Change in cycles is accompanied by change in the functions of the human organism and a person's working efficiency. Scientists have determined that from 40 to 50 physiological processes are subjected to fluctuations in the course of a 24-hour period. The work rhythm of the human organism changes twice: work during the day is the first rhythm, and work at night is the second. When this rhythm changes, changes occur in the activities of practically all of man's principal organs: heart, kidneys, endocrine glands, etc. Figure 4.3.2 contains a human biorhythm diagram.

Fluctuations of emotional processes take place synchronously with fluctuations of the physiological systems, affecting higher mental activity and a person's efficiency. In the process of evolution, man has developed two efficiency peaks: from 0900 to 1300 hours, and between 1600 and 2000 hours. A period of elevated physiological and psychological state is followed by a drop in a person's efficiency. A person makes the greatest number of mistakes approximately from 1300 to 1600 hours and from 2400 to 0400 hours. A person's labor productivity is lowest from 2200 to 0600 hours.

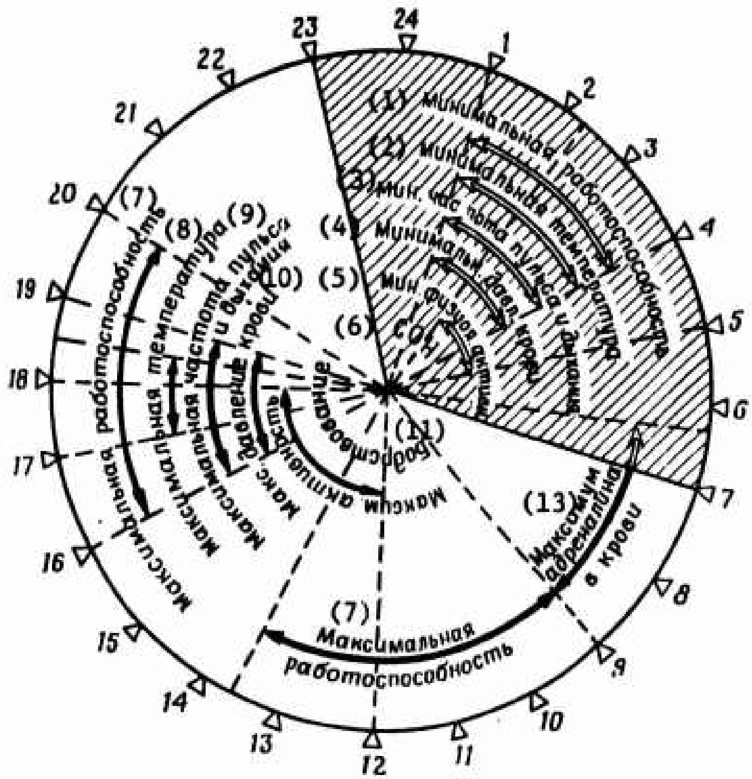


Figure 4.3.2. Human 24-Hour Biorhythm

Key:

1. Minimum efficiency
2. Minimum temperature
3. Minimum pulse and respiration rate
4. Minimum blood pressure
5. Minimum physiological activity
6. Sleep
7. Maximum efficiency
8. Maximum temperature
9. Maximum pulse and respiration rate
10. Maximum blood pressure
11. Waking hours
12. Maximum activeness
13. Maximum adrenaline in the blood

Tanker efficiency also drops off at night. Figure 4.3.3 contains graphs which describe change in the average speed, over the course of 24 hours, of two tanks (A & B), which possess different inherent speed capabilities. The greatest drop in tank speed occurred between 0100 and 0300 hours. In spite of the greater speed capabilities of tank A over tank B, their average speed during this time was practically identical. Evidently the substantial decline in activeness of driver sense organs is a factor.

Man developed a diurnal rhythm in the process of evolution. As they say: "Man is a day creature." During the day his labor productivity is high, while at night it drops off significantly. For many very important reasons, however, tank troops will be fighting, and especially moving, at night.

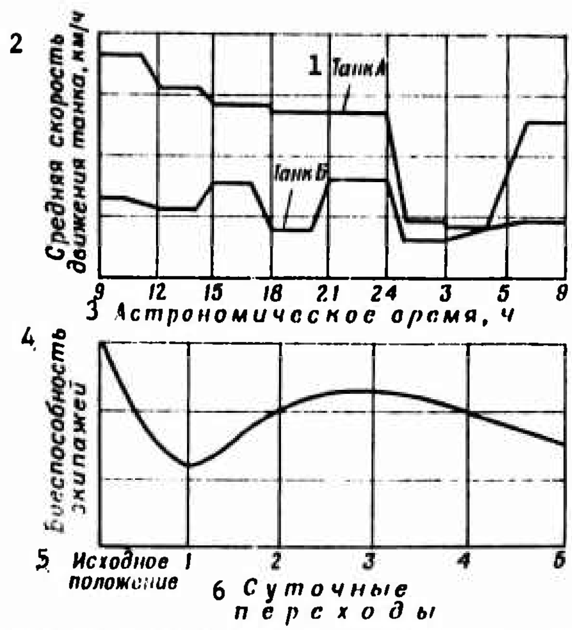


Figure 4.3.3. Change in Crew Combat Activity Performance Over a 24-Hour Period and by Periods of Performance of Combat Training Missions

Key:

1. Tank
2. Average tank speed, km/h
3. Astronomical time
4. Crew efficiency
5. Starting point
6. Daily march segments

The human organism is capable, under proper conditions, of developing a new rhythm of physiological functions, which provides an easier adaptability to work at night. In addition, not all individuals possess identical biorhythms; a certain percentage (approximately one sixth) work better during the day, some work better in the evening (one third), while one half of all persons adapt easily to any work schedule.

In order to avoid a sharp decrease in average tank speed at night, tankers practice operating tanks at various times, including at night. Assignment of relief drivers is made taking into account the individual features of driver efficiency. At night tanks are driven by regular and relief drivers showing better efficiency in the evening hours, or persons who easily adapt to working at night. Tank crew member productivity maxima and periods of psychophysiological decline are considered when planning long halts and extended rest (day's halt).

As is evident from Figure 4.3.3, significant changes in the organism's functions and efficiency of tank crew members are noted during the first march segment. During this period a discrepancy between psychophysiological processes and duties performed by crews is sharply manifested. As the march continues, crews improve their skills, and their actions become more economical. The tankers become accustomed to the job, as it were. They still have not developed, however, precise response actions to incoming information. Their organism responds to incoming signals in a non-optimal manner, with an overload. Seeking ways to reduce faulty actions, tankers develop optimal modes of actions. By the end of the first march

segment, tanker adaptability is replaced by a clearly-elaborated dynamic stereotype, tanker efficiency improves, as do march performance indicators. The duration of this period is approximately 24 hours.

The tankers subsequently become accustomed to ambient conditions. The organism begins to function in an optimal mode. Actions pertaining to performing duties become economical to a maximum degree. Tanker volitional efforts and level of efficiency stabilize. This period is characterized by maximum efficiency and by the highest march performance indicators. As a rule it begins with the second march segment, continues on the third, and ends on the fourth segment.

Depending on the loads affecting tank crews and the general and physical level of tanker training and proficiency, their level of efficiency begins to drop off as the march continues. Signs of fatigue appear on the third march segment. The organism becomes retuned, maintaining the requisite level of combat activity at the expense of weakening of less important functions. During this period there occurs compensation, as it were, for worsening of the state of the organism by acquired skills, with the influence of fatigue predominant. In spite of experience and know-how, disruption of coordination of movements occurs in crew members, and the number of faulty actions increases. Effectiveness of tank crew combat activity steadily declines.

Two phases are observed in change in the state of the organism and combat efficiency of tank crew members following a day's rest in the middle of an extended march: the first change occurs prior to rest, and the second occurs following rest. The pattern of change in efficiency is approximately the same for each phase, just as in executing a march without a day's rest, but at the second stage march performance indices are poorer than at the first. This indicates that over a period of 24 hours the functions of the organism of tank crew members are not restored to the initial level.

On the basis of the patterns of change in the efficiency of tank crew members over the course of 24 hours and from one march segment to the next, measures are elaborated to accomplish efficient organization of tank troop personnel combat activities.

Thus designing and building of equipment, aptitude testing in selecting candidates for armor occupational specialties, more efficient crew training, as well as selection of tank crew combat activity regimen in conformity with the laws of dynamic interaction of man and machine in combat, are the most important conditions for tank crews to utilize effectively and efficiently the combat performance characteristics of their tanks.

PART TWO. COMBAT EMPLOYMENT OF TANK TROOPS

SECTION V. TIME AND TANKS

Chapter 1. TANKS -- MAIN STRIKING FORCE OF GROUND TROOPS

Tanks first appeared toward the end of World War I as a means of close support of infantry. In the course of their subsequent evolution tanks were transformed, alongside aircraft, into a powerful means of achieving operational and strategic objectives.

In the course of World War II tank troops crossed deserts, plains, mountains and mighty rivers, and frequently faced the adversary with an unavoidable catastrophe.

Veterans of World War II remember well the explanataion: "Attention, tanks!" which ran up and down the chain of command whenever panzer units and combined units appeared on the battlefield. Since that time and up to the present date, tank troops have been the main striking force of ground troops.

What tank troops are to become, this steel cavalry of today and tomorrow -- depends on what role would be assigned to ground forces in the nuclear age. Today there exist in the most technically sophisticated foreign armies two points of view on the role of ground forces in the war of the future.

The first view is that nuclear weapons are considered a panacea for all ills, with the aid of which one can resolve all problems which arise in the course of combat. Proceeding from this, ground troops are assigned the role of occupation forces, which would enter enemy territory following a nuclear attack and take control of it. Hence conclusions are reached that ground forces should be small in numbers, light and adapted primarily for airlifting.*

The adherents of the second point of view, although acknowledging nuclear weapons to be the principal weapon to use against the adversary, believe that victory can be complete only when any enemy personnel surviving nuclear attacks are destroyed or captured, and firm control is taken over the enemy's territory. This will require considerable efforts on the part of ground troops, and consequently they should be equipped with all modern means of combat, particularly tank troops, as the best adapted for operations in a nuclear war.*

Advocates of the first view believe that it is enough for military police wielding clubs to appear on the battlefield following nuclear strikes, and the enemy will

* NATO'S 15 NATIONS, June-July 1972.

be brought to his knees. To confirm this view they usually point to the U.S. employment of atomic bombs on 6 and 9 August 1945 against the Japanese cities of Hiroshima and Nagasaki, continuing to claim that Japan allegedly surrendered following the dropping of these atomic bombs. In actual fact Japan surrendered almost a month after the atomic bombs were dropped (2 September 1945), after the Soviet Army had crushed the Kwantung Army, the backbone of Japan's land forces.

It is noted in foreign publications that one can scarcely count on a serious and powerful adversary capitulating following initial nuclear strikes. The contrary is more probable, that he will offer the most savage resistance, for only that army which is capable of fighting to the very end can gain victory. In this regard the majority of foreign theorists give preference to advocates of the second point of view. They frequently pose the question: What should ground forces be and what should they have as principal striking force? Some foreign military theorists view nuclear weapons as a means with the aid of which one can put an end to the traditional tactics of penetrations, conventional and double envelopments, as well as encirclements. Others accuse them of forgetting the lessons of the past: sooner or later any changes in forms of maneuver have always encountered corresponding countermeasures by the adversary. Just as the appearance of the musket forced abandonment of deep formations and invention of the machinegun forced abandonment of close columns and lines, the adoption of nuclear weapons led to the necessity of dispersing troop combat formations into separate groups. It is believed that as a result, selection of targets for nuclear weapons will be very difficult, especially for large-yield nuclear warheads. At the same time it is very difficult to determine the epicenters of nuclear bursts, since targets will be constantly moving on the battlefield, and therefore it will prove to be very difficult to destroy them, for a high-mobility target is capable, during the time from which it is detected to the moment a missile or nuclear artillery piece is fired, of leaving the nuclear warhead killing zone. It is pointed out that because of this, released nuclear warheads will frequently not hit the target, while enemy troops considered to be destroyed or disabled will appear in the path of the advancing forces.

Consequently, claim foreign military experts, in a future war nuclear strikes alone, even if all targets are hit, will be insufficient to gain total victory. A portion of the enemy's forces in the hit targets will survive. Although conventional weapons seem insignificant in comparison with nuclear weapons, nevertheless they are essential at the final stage of battle, when the advancing troops will come face to face with enemy troops which have survived nuclear strikes, or enemy reserves which the adversary has succeeded in concealing from the reconnaissance of the advancing force. Under these conditions it will be necessary to engage conventional weapons, and particularly tanks, to destroy the enemy with a swift and devastating tank assault. It is advisable to mount this attack before the adversary has recovered. Such was the case in the not so distant past, when heavy artillery was followed by the grenade, and the machinegun by the pistol and bayonet. This trend continues today.

It is noted that if any area is transformed into a dead zone or neutralization zone, in this instance as well it is possible that there will remain in the given area a pocket of resistance the capabilities of which should not be ignored. One should always count on an adversary who is strong in spirit for, as the saying goes, "if a soldier has an iron heart, even a wooden sword in his hand is a fearsome weapon."

In the past war the world was amazed time and again by the staunchness of spirit of Soviet troops who seemed to be doomed.

It is emphasized in foreign publications that counting on a rapid victory without substantial combat by ground troops may lead to disappointment if one assumes that nuclear weapons will fully open the way for maximum-speed troop advance. This will become possible if the enemy's morale is suddenly and totally destroyed with the first strikes. Consequently even under these conditions it will be necessary to employ ground troops and maneuver characteristic of ground troops.

The conclusion is reached that powerful ground troops possessing all weapons will be essential in a nuclear war. Their tactics are inconceivable without maneuver, that is, combination of fire and movement. It is believed that the need for powerful ground troops equipped with tanks in modern combat operations without employment of nuclear weapons has been proven by the events in Korea, Vietnam, and the Near East. All the above attests to the fact that in a future war ground troops will be assigned diversified missions.

At the present time ground forces in all the world's armies consist of various arms and special troops, which harmoniously supplement one another. And now it has been universally acknowledged that the main role in ground forces will be played by tank troops, which are the most suited for conduct of combat operations with and without the employment of nuclear weapons.

Today it is universally acknowledged that tank troops constitute the principal striking force of ground troops.* This is also attested by foreign theorists such as M. Taylor, [Zh. Nuare, F. Mikshe], and others.

At the present time a lively debate is continuing in all the armies of the world on the question of what tank troops should be and what their organization should be. Examined in this connection is the question of what equipment should be furnished to tank troops: should they have a single standardized vehicle or different types of combat vehicles?

In order to answer these questions, let us mentally picture tomorrow's battlefield, for war alone is a test of the correctness of military theories. The opinion is expressed in foreign military periodicals that in a nuclear world war nuclear weapons will be employed in large quantities for delivering strikes on troop concentrations, important segments of terrain, supply depots, communications centers, and other targets. Both nuclear ground bursts and airbursts will be employed. At the same time, combat operations may be conducted under conditions of threatened employment of nuclear weapons but without their actual employment. Even in conditions of nuclear war it is acknowledged that there may occur engagements in which only nonnuclear weapons are involved.

The situation on the battlefield, in the opinion of foreign military experts, will be characterized by the following features:

---

* See WEHR UND WIRTSCHAFT, July-August 1972.

almost a continuous threat of delivery of nuclear strikes of various yield in all battlefield areas;

effect of nuclear weapon casualty-producing elements on the troops: shock wave, luminous radiation, and penetrating radiation. Depending on the yield of a nuclear weapon, troops in an exposed position on open ground will be effectively knocked out of action at a distance of up to 3-5 km from ground zero, while troops located inside armored vehicles may survive and maintain their fighting efficiency even if they are three times closer to ground zero than troops not protected by armor;

radioactive contamination of the terrain as a result of nuclear fallout. A ground burst or airburst close to the ground will result in contamination of extensive areas, with a radiation level which may persist for an extended period of time and cause radiation sickness in unprotected personnel. Troops in armored vehicles, however, which attenuate the effect of radiation, can live and function in these conditions without being in danger of radioactive contamination;

an almost continuous threat of loss of entire subunits, supply points, communications gear, transport and communications centers, as well as disruption of rear services operations as a result of delivery of enemy nuclear attacks.

Proceeding from the above conditions, the conclusion is reached abroad that tank troops should have armament and organization which would enable them successfully to operate both in conditions with and without employment of nuclear weapons. A question arises in connection with this: with what combat vehicles should tank troops be equipped?

Views of foreign experts differ on this score. Some are advocates of three types of vehicles: light, medium and heavy tanks. Others believe that under the new conditions it is advisable to have only two types of vehicles -- light and main battle tanks, which should be medium tanks.

This question was extensively discussed abroad immediately following World War II and after nuclear weapons became operational. It is still being discussed today.

For a long period of time all countries subdivided tanks into light, medium, and heavy. In time it was becoming clear, however, that such a division is not quite accurate, for as years passed tanks which on the basis of weight had previously been considered heavy tanks had begun to be considered medium tanks. The majority of today's light tanks would have been considered medium tanks in the 1940's.

During and after World War II there was noted a tendency to subdivide tanks into light-gun, medium-gun, and heavy-gun. This classification was also rejected, since light guns had been mounted on heavy chassis: for example, the Churchill heavy tank carried a light 42 mm gun, the KV-1 and KV-2 heavy tanks carried medium 76 mm guns, while on the other hand a heavier 88 mm gun was mounted on the chassis of a light Czechoslovak tank, for example, and large-caliber howitzers were mounted on the chassis of T-34 medium tanks. Therefore today there is a tendency to classify tracked fighting vehicles on the basis of the missions they perform, subdividing them into reconnaissance, airborne assault, main battle tanks, support tanks, tank destroyers, assault guns, self-propelled antiaircraft guns, etc.

It is true that in a number of countries tanks are classified according to the old principle, and are subdivided into light, medium, and heavy (based on weight).

Adopting a tank classification according to missions, one can make a comparison only within a single group, designated for performing specific missions. Thus a large number of vehicles are excluded from comparison. Even under this condition, however, it is difficult to compare vehicles without an idea of the tactical concepts of a given country or several countries. Let us take, the well known French AMX-13 tank. It was designed as a tank destroyer and is still considered such in France. Other countries which have purchased this tank, however, use it as a reconnaissance tank (the Netherlands and Switzerland) or as a police vehicle (Venezuela).

A lively debate is still being conducted in the foreign military press on what kind of tanks are needed in the nuclear war era. The performance characteristics of nuclear weapons and antitank guided missiles, which are capable of piercing armor of practically any thickness which can be placed on tanks, have forced military theorists and designers to ponder the following basic questions: What is more important for a tank -- mobility or armor protection? What are the best types of vehicles to have? What armament should a tank carry -- gun or missile?

Many experts abroad advocate designing and building primarily light tanks armed with powerful antitank guns in combination with antitank missiles. The supporters of this concept proceed from the position that for all practical purposes any tank can be killed by modern antitank missiles. And if this is so, in their opinion there is no sense in building tanks with thicker armor. But they are considering only one aspect of the matter -- tank survival against missiles. But a tank will encounter on the battlefield not only antitank missiles. In the harsh reality of combat, with soldiers subjected to considerable psychological stress, the tank should be a kind of mobile pillbox.

It is believed that light tanks, as a consequence of inadequate armor protection and armament, are unsuited for combat against a powerful adversary and are not adapted for negotiating obstacles which may result from the employment of nuclear weapons.

Foreign military theorists believe that a medium tank can affect personnel on the battlefield both psychologically and with its firepower. Carrying a more powerful powerplant, it does a better job of crossing difficult terrain than a light tank. Tanks are capable of dominating action on the battlefield if they are sufficiently heavy and can withstand the shock wave of a nuclear burst, and they can also provide the crew with good protection against penetrating radiation. Otherwise neither their maneuverability nor speed will help them.

In the opinion of foreign military experts, tanks, especially medium and heavy tanks, give adequate protection against alpha, beta, and gamma radiation, as well as against biological and chemical weapons; the question of protection against neutron flux has not yet been determined. Tanks can withstand a nuclear attack better than other weapons and can also cross devastated terrain and ground contaminated by radioactive substances.

At the present time a trend toward standardizing combat vehicles is observed in all the world's armies. They are endeavoring to design multirole vehicles

capable of performing three basic missions: conducting reconnaissance, performing combat support service, and fighting in coordination with other weapons.

As is noted in the foreign press, however, in the near future it will be impossible to accomplish complex combat missions with a single type of armored fighting vehicle. It is impossible to design an armored fighting vehicle with good armor protection and powerful armament which would be amphibious and air transportable. In order to perform the above combat missions, one should possess several types of combat vehicles. As regards selection of tank design, for an objective evaluation it is necessary to employ the probability approach, that is, to determine probability that a tank will perform its mission in combat as a whole or at least at one stage of combat.

It is believed that such an approach would make it possible most correctly to evaluate many tank performance characteristics and will provide objective quantitative criteria for comparison of the design of various vehicles. Employment of mathematical operations research methods will help resolve this problem.

Killing enemy tanks is considered to be the most difficult of the tasks performed by tanks. Therefore it is recommended that one adopt as principal criterion of a tank's effectiveness its capability to destroy enemy armored vehicles. This can be adopted as the principal criterion because tanks capable of sufficiently effectively killing enemy tanks will also be effective in performing other missions. Thus tank design should be evaluated proceeding from the probability indices of effectiveness of killing enemy tanks and personnel encountered on the battlefield.

Chapter 2. TANKS IN A FUTURE WAR

The fact that the tank -- that diesel dinosaur -- remains master on the battlefield seems paradoxical in our space age. This is due to the fact that the tank, because of its performance characteristics, is most suited for the conduct of combat operations under conditions of nuclear war.

It is noted in the foreign press that in spite of persistent efforts, these efforts have been unsuccessful in resolving once and for all the problem of combat against tanks. For this reason tanks and the threat of tank employment continue to retain their significance. Taking into account the opinion of foreign military theorists on the place and role of tanks in a future nuclear war, we shall note that in the conduct of combat operations by ground forces, a leading role is assigned to tanks, for it is precisely tank troops, constituting the main striking force of ground troops and working in close coordination with other arms, which will swiftly advance on the heels of nuclear strikes, overwhelming as they advance enemy pockets of resistance which have survived the nuclear strikes or operational reserves which have advanced from depth. Tanks will be the first to cross enemy contamination zones and to come to the assistance of airborne assault forces delivered deep behind enemy lines.

Tanks are a powerful weapon capable of fighting under any and all conditions. The experience of past battles indicates that they have successfully operated both on the plains of Europe, in the deserts of Africa, and in the mountains of Asia.

The situation will also not be ideal on future battlefields, and therefore the necessity of utilizing tan'-s to achieve success in the complex conditions of contemporary reality should be comprehended by all those who endeavor to see the prospects for victory. It is impossible to achieve victory under present-day conditions without tanks.

Many of the most highly equipped modern armies recognize the fact that tank troops can be employed in combat as divisions as well as in larger units.* Tank combined units should be the foundation of these units, but at the same time their composition should include units and subunits of other arms. Such units should constitute powerful combat elements. In the course of battles they should maintain

* See NATO'S 15 NATIONS, June-July 1972.

their offensive capabilities to split up, disorganize and destroy enemy troops. The end objectives, which determine success in combat, have remained unchanged: the adversary should be destroyed or compelled to surrender.

Consequently only situation conditions and combat equipment have changed. But as a consequence of the development of nuclear weapons, these changes are enormous in scale. We should note that mobile tank troops equipped with modern weapons can today perform more complex missions. This is a very important change in the role of tank troops in comparison with their role in the past war.

Of course the combat power of tank troops can be utilized most effectively on a plain, with good roads and bridges, and on terrain lacking major obstacles. The commander, who will need to decide how to achieve more effective utilization of his combat capabilities and to reduce to a minimum the influence of adverse conditions, should be able correctly to estimate these conditions on the battlefield.

We know that successful tank operations are hindered by highly broken terrain -- deep ravines and erosion gullies, permafrost, thick undergrowth, deep rivers and lakes, canals, walls and built-up areas. Achievement of maximum effectiveness of tank troops is promoted by an intelligent and innovative approach to utilization of terrain conditions and materials at hand. When combat operations are being planned for difficult terrain, particular importance is assumed by such elements as key areas of ground, conditions of observation, sectors of fire, obstacles, shelters from fire, means of camouflage and concealment, and approach routes (including the road network). As a rule, the more difficult the terrain, the more detailed planning should be.

In any case, in order to decrease the influence of adverse terrain conditions on troop operations, it is essential thoroughly to work out matters of tank supply and recovery, rear services and engineer support. The problem of roads will become particularly complex, and therefore it is important to provide for utilization of materials at hand to improve the cross-country performance of armored vehicles.

The success of tank combat operations will be greatly influenced by prompt supply of fuel and lubricants, ammunition, as well as other supplies. The experience of the war provides many examples of tank units which advanced swiftly and then were forced to stand idle, waiting for fuel and lubricants, ammunition and rations to be resupplied by air. In this regard the experience of the past war is useful today as well and must be taken into account.

The advance of forces possessing a large number of tanks may frequently develop along separate axes, sometimes isolated from one another. In performing their assigned missions they may break contact from the other advancing forces. This separation will be of the nature of unscheduled separation of tanks from the remaining advancing forces and penetration deep into the adversary's dispositions, and will comprise swift forward movement, by bounds, following defeat of each encountered enemy force. Foreign experts believe that the offensive will be of the nature of an advance by tank columns on a broad front and at considerable depth, and there will be no well-defined forward edge of the battle area as was the case in past wars. Operations will develop in separate areas.

Many foreign authors are of the opinion that in connection with the fact that an offensive will develop along separate axes and will assume a focal nature, where enemy mechanized and tank subunits and units may operate between advancing tank subunits, the term "capture of ground" loses its former meaning. Any area occupied by troops will comprise a favorable target for a hostile nuclear strike. At the same time large areas for all practical purposes cannot be held by dispersed troops. The term "to occupy" terrain yields, as it were, to the term "control." An area of terrain will be called controlled by tank troops if the enemy is unable to penetrate into that area and, if he does penetrate, he will be destroyed.

It is pointed out that dispersion of troop dispositions will constitute one of the principal guarantees of tank survival in the course of combat operations. Even this guarantee is relative, however. In order to determine an adequate degree of dispersal, one must know the yield size of the enemy's nuclear warheads. Therefore dispersal of troops is always essential. The greater this dispersal is, the more difficult it will be for the adversary to detect targets and to mount a strike. At the lower echelons such dispersal should enable an undispersed subunit to perform the simple tactical mission of destroying an adversary who has initially been hit with a nuclear strike. There should be some limit to dispersion, however. It is believed in many foreign armies that the battalion could constitute this limit. In the final analysis the scale of dispersion should be selected in relation to the possible size of hostile nuclear warheads as well as the nature of the terrain.

Defense in the war of today, it is believed abroad, is losing the more or less static character it formerly possessed. An offensive character should be grounded in the principles of conduct of the defense. Tanks will play the most critical role in defensive operations of ground forces -- destroying, in coordination with other arms, enemy forces which have penetrated the defense, and reestablishing the original situation. In addition, with favorable conditions tank troops, having restored the situation of the defense, can continue the attack and thus create conditions for shifting of troops to a counteroffensive.

In the last war we had similar precedents, where a counterthrust by the 5th Guards Tank Army and 5th Combined-Arms Army at Prokhorovka in July 1943 reached the exploitation stage, and the defending troops of the Voronezh Front shifted to a counteroffensive.

Such elements are particularly possible in a future war, since defending forces may create with their nuclear weapons conditions for a shift to a counteroffensive.

Examining the role of tanks in a future war, one should bear in mind that mobility is one of the principal characteristics of tank troops. It enables them successfully to accomplish missions both in the attack and in the defense. In a number of instances attempts are made to represent the mobility of tank troops as a universal means which guarantees their survivability.

There exists abroad a tendency toward even greater increase in troop mobility, even at the expense of reducing the armor protection of tanks and other armored fighting vehicles. It is noted, however, that this is a very dangerous trend, for its advocates forget that troops in movement are subjected to greater danger of being hit by nuclear weapons than troops in place.

It is pointed out in the foreign press that mobility cannot be continuous. This would lead to rapid exhaustion of personnel and wear and tear on equipment. Hence the conclusion is reached that mobility can constitute a factor of survival of tank troops only in the degree to which it deludes the adversary as regards the location of troops and enables a spotted unit rapidly to leave a given area before the adversary delivers a nuclear strike. Shelters provide more reliable protection. Mobility and sheltering vehicles in the ground are two different methods of ensuring tank safety, which must be skillfully combined in a nuclear war.

One should also bear in mind that control of tank troops assumes enormous importance in a nuclear war. The opinion has been expressed in the foreign military press that planning of combat operations should be reflected rather in directives than in orders.* These directives must define as precisely as possible missions, principal features of actions, and the stated objective. Upon commencement of an operation, subordinates must be granted the most extensive initiative, since they alone are capable of understanding a highly complex situation. Decentralization of control will become essential right down to the lowest organizational echelon. Therefore directives should be absolutely clear, so that there is no confusion. Thanks to this, tank troops operating on the battlefield will be able to make their contribution toward accomplishing the common task and achieving final success.

It is believed that centralization in preparing for and decentralization in conduct of an operation are important demands in a nuclear war. Under conditions of conduct of combat operations by tanks along axes and at considerable depth, when combat actions will be conducted in separate areas and communications will be disrupted by the enemy, it will be very difficult for the command to get its bearings in this complex and confused situation even if it maintains control. This is an additional argument in favor of decentralization of control of combat operations, which should be thoroughly prepared for in advance; otherwise troop activities will be paralyzed several hours after the commencement of an offensive. Therefore under all conditions tank units operate in an organized manner, taking assigned missions into account and attacking the adversary with all available weapons.

Foreign military experts believe that under conditions of a future war rear services support of tank combat operations will be of decisive significance. The conventional rear services system, based on deployment of large supply depots and hauling supplies great distances, may prove unsuitable. In a future war large supply depots will be highly vulnerable, while hauling supplies large distances will be made difficult due to disruption of lines of communication. Alongside dispersion of troops, decentralization of supply depots will prove essential, replacing large depots with a large number of multipurpose facilities suitably distributed over a large territory.

It is believed that extensive employment of air transport will prove advisable in order to compensate for disrupted operation of ground transportation. Air-supplying tanks which have penetrated deep into the enemy's dispositions may prove to be

* See [Zh. Nuare,] "Features of War and Armies of the Future," REVUE DEFENSE NATIONALE, January-February 1963.

the core of the problem. Of course this by no means excludes employment of cross-country vehicles for hauling supplies to tanks engaged in combat.

It is noted that a substantial deficiency in rear services support will occur on battlefields where tanks will be operating, of course to a differing degree and in different areas, which will threaten to halt tank combat activities, as they cannot operate without fuel and ammunition resupply. Under these conditions extensive maneuver of supplies by air once again can eliminate this danger. Logistical support should be set up in such a manner that tanks are not immobilized due to a lack of fuel and especially ammunition.

Of course tank troops which have driven far forward can utilize supplies from captured enemy stores, which has been the case in past wars and will be extensively employed in the future as well. But nevertheless this must be viewed as a chance source, for the enemy, when supplies are threatened with capture, will always attempt to destroy them.

It is noted that airborne and amphibious assaults will be extensively employed in a future war. When employing airborne assaults, tanks will constitute a cementing nucleus around which airborne and naval infantry will group. It is pointed out that there is occurring a rapid process of equipping airborne assault troops with armored vehicles. It is true that at the present time airborne assault troops in the armies of a number of capitalist countries have at their disposal only light tanks and self-propelled guns which can be both dropped by parachute and airlifted by fixed-wing and rotary-wing aircraft.

It is claimed that airborne assault forces armed with light tanks, self-propelled artillery and armored personnel carriers will be highly mobile and maneuverable. Airborne assault force tanks will be able to perform very critical missions behind enemy lines, swiftly moving from one location to another. Airborne assault subunits equipped with tanks can be considered the principal striking force of airborne assault forces.

It is noted in foreign military periodicals that transport aircraft are being designed for airlifting AMX-30, Leopard and type S medium tanks. Airlifting such vehicles will alter the character of airborne assault operations. Some military theorists and practical experts believe that in the future an offensive will apparently be mounted by air.* Tank units and subunits will be used primarily, since under present-day conditions only mechanized units will be capable of mounting a genuine offensive upon landing. Elaboration of theory of swift engagement by airmobile divisions is viewed as a first step in resolving this problem.

It is noted that in order for airborne troops to be able fully to implement their specific advantages, they should contain tank units and subunits equipped with armored vehicles. Without this, airborne assault forces will be able to perform only those missions which are within the capabilities of conventional airlifted motorized infantry units.

---

* See B. Rigg, "War of the Future," MILITARY REVIEW, September 1975.

The past war, as well as events in the postwar years, attest to the enhanced role of amphibious assaults, in the opinion of foreign military theorists. It is believed that tanks will play one of the main roles during landing of amphibious assault forces and their actions on shore.

In the past war, when tanks were equipped with primitive flotation devices, efforts were made to utilize them in the forward echelons of amphibious landing forces. Foreign military experts believe that this trend has become intensified in the nuclear age and that today it is essential to land tanks and other amphibious armored vehicles in the first waves of amphibious landings. No other weapon can so rapidly and effectively exploit the results of nuclear strikes upon landing as tanks are capable of doing.

It is noticed that tanks and armored personnel carriers protect personnel from machinegun fire, shell fragments and bombs. Therefore it is advisable to have amphibious tanks and armored personnel carriers in the first waves of amphibious landing forces, disembarking from landing ships while still at sea and proceeding to the beach under their own power. Many foreign military experts believe that to achieve a rapid buildup of efforts by an amphibious landing force and to deliver a swift strike on shore, it is also advisable to land tank subunits in subsequent waves of an amphibious landing, utilizing tank landing ships and craft for this purpose.

At the same time development of amphibious armored vehicles (tanks and armored personnel carriers), as well as various flotation equipment for tanks, in the opinion of many foreign military experts, opens up new prospects for utilization of tank troops in amphibious landing operations, utilizing them as independent amphibious landing forces.

Hence the conclusion is reached that tank troops, constituting the main striking force of ground troops, can also play a major role in landing airborne and amphibious assault forces.

Chapter 3. TANK TROOPS DEVELOPMENT PROSPECTS

In spite of the fact that the cost of a tank is increasing due to constant improvement and that some foreign military theorists believe that the tank is a weapon system which has become obsolete for modern combat, they claim that the tank will continue for a long time to come to be a principal weapon of all the world's armies. This is determined by the fact that there does not yet exist nor is there foreseen a cheaper and more powerful weapon system which could compare to the tank in its performance characteristics and which would be capable of providing high mobility, protection against hostile fire, considerable firepower and all-weather, day-and-night operational capability in various types of combat.

Foreign military experts believe that the main question is to determine what direction to follow in elaborating requirements on the tank of the future. All agree on one point: the tank of the future should be sufficiently inexpensive to build, simple in design, should be highly survivable, and should be capable of firing and hitting the target while on the move and killing moving targets at considerable range; it should carry the most advanced night vision devices and daylight optical instruments, giving day-and-night operating capability.

The extensive adoption of nuclear weapons has produced two opposing points of view on the part of theorists and practical experts in military affairs of a number of foreign armies. These points of view have correspondingly given rise to two opposing trends in the development of tank troops. The first trend consists in the following: as a consequence of enhancement of the role and significance of armored vehicles, especially tanks, and their recognition as the best means of waging combat in a nuclear war, there has appeared an endeavor to achieve maximum "armoring" of troops, that is, to equip them with armored fighting vehicles. It would seem that this trend should promote further development of the organizational structure of tank troops. This has not occurred, however.

Only a portion of military experts in various countries, on the basis of the lessons of World War II, have retained their faith in tank troops and advocate their further development and improvement. These experts definitely see that tanks will play the main role in ground forces in war. They also believe that tanks are not the same as tank troops.

Tank troops are specially organized, cohesive and trained subunits, units and combined units equipped with armored vehicles and other weaponry. The strength of tank troops lies in their special training, cohesiveness and ability to conduct

swift combat actions in columns, in approach march and combat formations, in their compactness, mobility and maneuverability, multiplied by the iron will of men willing to operate far behind enemy lines, separated from other troops and without supply. It is precisely this which distinguishes them from other ground arms.

Proponents of the second trend, although acknowledging the role and significance of tanks as a means of combat, believe that ground forces should consist of unified, standardized divisions containing a large quantity of armored equipment. They proceed from the position that they consider nuclear weapons to be capable of accomplishing the majority of missions which arise on the battlefield. In their opinion standardized divisions should perform the mission of occupation troops, which will enter an area where the outcome of combat has already been decided by nuclear weapons. The adherents of this concept propose that these divisions be equipped with one or two types of standardized combat vehicles.

The development of antitank guided missiles and other antitank weapons intensified to an even greater degree the competition between tanks and their antipodes. According to figures published in the foreign press, antitank guided missiles can penetrate armor up to 600 m thick. It is believed that they can kill any tank. As a consequence of this, there have appeared advocates of manufacture and adoption only of lightly armored and well-armed vehicles.

Although there has presently crystallized in foreign periodicals the view of development of a main battle tank which can satisfy to the greatest degree the conditions of combat in a nuclear war, nevertheless the debate continues. This is natural, for the dialectics of life consist in seeking the truth by comparing different points of view. And this must be acknowledged as correct, for the struggle of opinions always exists in life.

It is noted that it is the job of designers to design combat vehicles, while the role of commanders is to assign tasks to the designers, proceeding from prospects of and views on the future. The thinking of commanders should be directed toward the future. Only under these conditions will designers be able to design vehicles which meet the future conditions of warfare. Continuous creative elaboration of views on organization, combat utilization and equipping of tank troops of the future is therefore natural.

At the present time many foreign theorists and practical experts have reached the conclusion that tactical concepts require development of a tank which is lighter than existing heavy vehicles, a tank which runs on a more advantageous fuel, which possesses better cross-country capability in all weather, has a greater range, better observation and firing instruments, more powerful armament, an automatic loader, and better armor protection. It is claimed that the tank of the future should possess even greater survivability.

The question of tank survivability is determined by the interrelationship of such characteristics as mobility, height of silhouette, slope angle and quality of armor, as well as tank layout. The Americans, for example, employed a new design employing spaced armor, placing fuel in protected (self-sealing) tanks, isolating compartments with bulkheads containing special hatches, and providing ammunition

stowage with fire-fighting devices in order to improve tank survivability and achieve the least vulnerability.

Analysis of foreign military publications indicates that many military experts agree on the impossibility of accomplishing with one type of armored vehicle complex and diversified combat missions. It is considered advisable at least in the foreseeable future to have two types of combat vehicle -- a light tank and a main battle tank.

It is noted in the foreign press that many missions in combat operations with employment of nuclear weapons cannot be accomplished utilizing only complex combat vehicles. On the contrary, in the exceptionally difficult conditions of nuclear war a simple, easily maintainable weapon may prove to be the most reliable. Designers of tanks and other combat vehicles must bear this in mind.

As regards the organization of tank troops, an analysis of the foreign military press shows that there are two points of view on this question. One point of view states that the tank brigade* should be the highest tactical armor unit in a nuclear war. The other point of view is that tank divisions are the most advisable organization. Both views acknowledge the possibility of establishing of brigades and divisions more powerful tank forces. Tank troops will constitute the principal striking force of ground troops, while motorized infantry will be the binding element between separate armor forces.**

Foreign military experts believe that under present conditions and in the foreseeable future victory can be won only by the unified efforts of the various arms, including divisions of various designation.

Just as the unity of life in the universe consists in the diversity of its forms, so does the unity of victory consist in concentration of efforts of forces and weapons which are diversified in designation. This circumstance leads to the conclusion that the organization of divisions of ground forces with one-sided directional thrust will scarcely promote achievement of victory over the adversary. Proceeding from this, the opinion is expressed in the foreign press that under present-day conditions and in the immediate future it is advisable to maintain divisions of various designation in the ground forces, while tank troops should be utilized to spearhead drives mounted by ground troops.

Thus, as follows from analysis of the foreign military press available to the public, under present conditions and in the immediate future tank troops will constitute the main striking force of ground forces. They will also play a leading role in the landing of airborne and amphibious assault forces. It is believed that a light tank and main battle tank, as well as armored personnel carriers and infantry combat vehicles each accommodating a squad, should be the principal types

---

* See [F. Mikshe], "Reports on Organization of Future Ground Forces," WEHRKUNDE, No 6, 7, 1966.
** See [Kh. Oferrell and G. Derrou], "Armor Operations in Adverse Conditions," MILITARY REVIEW, February 1969.

of tank troops combat vehicles. These vehicles should be amphibious and air transportable.

In the opinion of many foreign theorists, the armor division will constitute the highest tactical combined unit. Proceeding from concrete situation conditions and combat situation requirements, larger armor forces may also be established. Tank troops should always seek to utilize such inherent characteristics as mobility, enormous striking power, firepower, and armor protection.

SECTION VI. COMBAT OPERATIONS OF TANK TROOPS

Chapter 1. NUCLEAR WEAPONS AND TANKS

1. Nuclear Weapons and Their Casualty-Producing Elements

Weapons the effect of which is caused by the release of energy in processes taking place within the nuclei of the atoms of certain elements are called nuclear weapons. As we know, in the detonation of conventional explosives, energy is released as a result of chemical reactions.

Devices designed to effect the explosive process of liberation of energy within the atomic nucleus are called nuclear warheads. There are two principal types of nuclear warhead, differing in character of explosive reaction: fission nuclear warheads (atomic warheads), and thermonuclear. In fission-type nuclear warheads, energy is released as a result of fission reaction of the nuclei of atoms of certain heavy elements (plutonium 239, uranium 235, uranium 233, etc). In thermonuclear warheads, in addition to a fission reaction, there occurs a fusion reaction of atomic nuclei of certain light elements (lithium, hydrogen isotopes -- deuterium and tritium, etc). Combined nuclear warheads are also possible.*

Nuclear explosions are accompanied by the release of a vast amount of energy. The yield ratings of nuclear warheads are determined not by their mass or size (caliber) but by the quantity of energy released when they explode. It is compared with energy released in the explosion of the most widespread explosive, TNT. The power of a nuclear warhead is measured in a TNT equivalent, the amount of TNT in tons (in thousands of tons -- kilotons; in millions of tons -- megatons), the explosion of which releases an equal amount of energy as in the explosion of a given nuclear warhead.

According to reports in the foreign press, at the present time there exist nuclear warheads with TNT equivalents ranging from several tons to tens of millions of tons (megaton). As we know, in August 1945 the Americans dropped atomic bombs with a TNT equivalent of 20,000 tons (20 kt) on the Japanese cities of Hiroshima and Nagasaki.

The following can carry nuclear warheads in the armies of the capitalist nations: missiles of various designation, aircraft bombs, artillery shells, torpedoes, and mines (nuclear landmines).

* See M. Namias, "Nauka i oborona" [Science and Defense], Moscow, Mir, 1969.

Nuclear warheads can be exploded in the air at low and high altitudes, at the ground (water) surface, and underground (under water). The external picture of a burst differs for different types of explosions.

The following casualty-producing elements are produced from the burst of a nuclear warhead: a powerful shock wave, luminous radiation, penetrating radiation, an electromagnetic pulse, plus radioactive contamination of the ground and objects. The blast wave causes casualties, destroys or disables combat equipment, weapons and structures. Luminous radiation causes fires, burns the skin, damages the eyes and causes temporary blindness in humans and animals. Penetrating radiation (gamma rays, neutrons) cause radiation sickness in personnel. Radiation is given off from contaminated ground and objects, producing the same effect on humans as penetrating radiation at the time of a nuclear burst. Radioactive dust particles can enter the organism of humans and animals together with air, water and food and can cause damage.

Penetrating radiation ionizes the atoms of the medium through which it passes. The degree of ionization of a medium is determined by dose of penetrating radiation, measured in roentgens. A roentgen is a radiation dose with which approximately 2 billion pairs of ions are formed in one cubic centimeter of dry air under standard conditions.

The casualty-producing effect of penetrating radiation on humans and animals depends on the magnitude of the received dose and the time in the course of which it is received.

The electromagnetic pulse damages control and communications equipment and disables radioelectronic gear.

The casualty-producing elements of a nuclear burst differ one from another in character, time and range of effect on personnel, combat equipment, weapons and structures, depending on the location (ground zero) of the burst.

The casualty effect of shock wave, luminous radiation, penetrating radiation and electromagnetic pulse is estimated on the basis of radii and areas of lethal areas. Depending on the yield of a nuclear warhead, type of burst, character of stricken objects and their degree of protection, the radii of casualty and damage effect, according to figures published abroad, will range from tens of meters to tens of kilometers (Figure 6.1.1). To estimate personnel casualties, one employs radii of zones of general effect of shock wave, luminous radiation, and penetrating radiation.

Warhead yield, type and location of burst relative to the target are determined by the mission, with the objective of inflicting maximum damage under the given conditions.

Radioactive contamination of terrain (water, equipment, etc) can occur over large areas and at considerable distances from ground zero (tens and hundreds of kilometers) and can affect personnel for an extended period of time. This is determined by the yield and type of burst, wind direction and velocity.

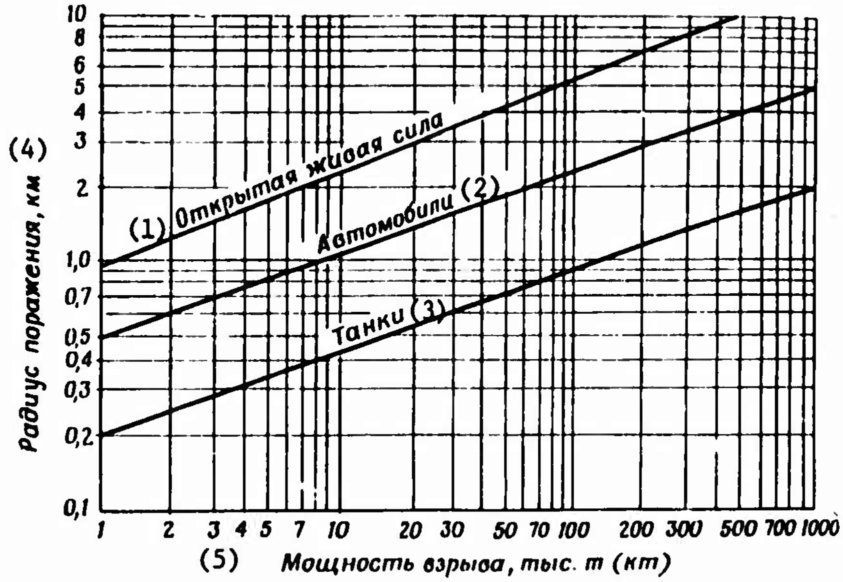


Figure 6.1.1. Nuclear Burst Damage and Casualty Radii*

Key:
1. Exposed personnel
2. Trucks
3. Tanks
4. Damage/casualty radius
5. Yield of burst, thousand tons (kt)

In addition, a zone of physical destruction and tree blowdown, which presents advancing troops with a substantial obstacle, is created in nuclear strike areas.

The destructive power of nuclear weapons is many times greater than that of shells and bombs carrying conventional explosives. For example, dozens of guns and mortars were employed during World War II to neutralize a well equipped strong point, thousands of shells would be expended, and considerable time would be required. Today this mission can be effectively accomplished in short order with a single nuclear warhead of appropriate size. Several nuclear warheads are capable of putting a unit and even a combined unit out of action.

2. Protective Properties of Tanks Against the Casualty-Producing Elements of Nuclear Weapons

Of all types of modern combat vehicles, the tank possesses the greatest resistance to damage and casualty-producing factors of a nuclear burst and provides the most reliable crew protection. A tank fully protects its crew against luminous radiation and substantially attenuates the effect of the shock wave and penetrating radiation. The tank's airtight seal protects the crew against radioactive dust entering the organism together with inspired air and against coming into contact with exposed parts of the body.

* Table based on figures from: M. Namias, "Nauka i oborona."

Tanks sustain structural damage from a nuclear burst at comparatively close distances from ground zero, as a result of the powerful shock wave. According to figures in the foreign press, for example,* tanks sustain considerable damage with a shock wave overpressure exceeding 2-3 kg/cm^2 (20-30 t/m^2). The overall force of impact on a tank in such instances exceeds 100 tons, which overturns it or throws it back several meters. Tanks sustain minor and medium damage with a shock wave overpressure of 1-2 kg/cm^2 (10-20 t/m^2). With damage of this magnitude, tank mobility is usually preserved. For example, with approximately 30 kt nuclear warhead bursts, heavy damage is observed within a radius of up to 250 meters from ground zero, medium damage -- up to 500 meters, and slight damage -- up to 1000 meters. On the basis of the law of similarity, radii of damage/casualties with two warheads exploding relate to one another as the cube roots of their yields:

$$r_1 : r_2 = \sqrt[3]{q_1} : \sqrt[3]{q_2} = \sqrt[3]{q_1 : q_2},$$

where r_1, r_2 -- casualty zone radii; q_1, q_2 -- warhead yields corresponding to these radii.

Utilizing this property, one can calculate the casualty zone radii of objects if the casualty zone radius is known for a given warhead yield. For example, with the burst of a 300 kt nuclear warhead, the radius of the casualty zone will increase not 10-fold in comparison with that of a 30 kt warhead, but only

$$\sqrt[3]{300:30} = \sqrt[3]{10} \approx 2 \quad \text{twice.}$$

Consequently, with a 300 kt burst, considerable damage to tanks will be observed within a radius 2 x 250=500 m, medium damage -- 2 x 500=1000 m, and slight damage -- 2 x 1000=2000 m.

A material's protective properties against penetrating radiation are determined by the half-value thickness. This is a thickness of a given material which cuts a radiation dose in half. Knowing the half-value thickness d_0, one can calculate the attenuation factor k of a barrier of any thickness d of that material according to formula

$$k = 2^{\frac{d}{d_0}}.$$

It is noted that the half-value thickness of armor is 3 cm for gamma rays and 10 cm for neutrons. Consequently armor with a thickness d=20 cm attenuates gamma rays $k_{g-r} = 2^{\frac{20}{3}} = 2^{6.7} \approx 100$ times, and a neutron flux -- $k_n = 2^{\frac{20}{10}} = 2^2 = 4$ times.

Materials consisting of elements with light nuclei do a better job of attenuating neutron fluxes than gamma rays. For example, the half-value thickness of certain plastics is d_0=3 cm for neutrons and d_0=15 cm for gamma rays. A layer of such plastic 10 cm thick attenuates a neutron flux approximately $k_n = 2^{\frac{10}{3}} = 2^{3.3} \approx 10$ times.

According to data in the foreign press, some modern tanks attenuate radiation doses approximately 10-fold, which provides sufficiently reliable crew protection during operations in radioactive contamination zones following nuclear strikes.*

* M. Namias, "Nauka i oborona."

A further increase in the strength and stability of tanks and their protective properties against the effect of penetrating radiation on crew members is needed to increase survivability of tank troops in conditions of employment of nuclear weapons. Materials containing elements with heavy and light nuclei are employed abroad for accomplishing this task.

3. Utilization of Tanks During Employment of Nuclear Weapons

It is undisputed that arming tank troops with nuclear weapons decisively increases their firepower and striking power and radically alters the content and character of modern combat. Tanks, which are more resistant to the casualty-producing elements of the nuclear burst, can most effectively exploit the results of nuclear strikes delivered on the adversary and secure conditions for his total defeat. The principal content of the combined-arms engagement will be destruction of the adversary's nuclear weapons and main forces with nuclear strikes, with a subsequent swift tank advance through breaches opened in the enemy's defense.

It is believed that missile and artillery subunits of tank troops should possess a high degree of mobility and be positioned in the tank combat formations. In addition, nuclear airstrikes can be delivered against enemy mobile targets for the benefit of tank troops.

It is stated in the foreign literature that nuclear weapons will be employed against the most important enemy targets. Such targets in the offensive engagement include nuclear weapons, strong points and centers of resistance, reserves, artillery and tank subunits, control facilities, and supply depots; in the defense -- nuclear weapons, attacking forces during their approach and deployment, and reserves.

Foreign experts believe that high airbursts will be most frequently employed in offensive types of combat actions: in the area of the bursts the ground is contaminated to an insignificant degree, which will present practically no hindrance to the advance of tanks. Low-altitude airbursts can be employed against solid defensive works and tanks. In a number of instances contact surface bursts will be employed against important targets deep in the enemy's defense. The adversary will additionally sustain numerous casualties from heavy contamination of terrain.

As a result of nuclear bursts, enemy subunits and units will fully lose their battleworthiness within the boundaries of personnel disabling casualty zones. Troops will be neutralized over a substantial area and for a certain period of time will be unable to offer organized resistance to the advancing forces.

Tanks alone are capable of swiftly attacking the enemy through breaches on the heels of nuclear strikes, of destroying surviving enemy personnel and weapons, of crossing radioactive contamination zones and tree blowdown, and reaching the opposite side of the nuclear burst area in the shortest period of time.

It is believed that when tanks emerge from a nuclear strike zone, they may encounter organized resistance by surviving antitank weapons or weapons moved up from the reserve. These weapons should be immediately destroyed by concentrated tank and artillery fire, while advancing reserves should be destroyed by missile and airstrikes. Only decisive offensive actions by tanks and their rapid pace of

advance will prevent the adversary from restoring his battleworthiness following a nuclear strike and will ensure his defeat.

With the employment of nuclear weapons it is essential strictly to observe safety procedures for friendly troops. Nuclear strike targets, warhead yields, as well as types of bursts are selected taking into account the safety of friendly troops. Troop safety lines are figured in advance and marked on the map and on the terrain on the basis of prominent landmarks (Figure 6.1.2). Taking into consideration the fact that terrain possesses substantial protective properties against the casualty-producing elements of a nuclear burst, one must skillfully utilize it to reduce friendly troop casualties. At the same time one must bear in mind that the terrain will change substantially in the nuclear strike area: entire structures and even built-up localities will disappear, certain bridges will be destroyed and woods will burn. The result will be that no landmarks will remain, creating substantial difficulties for advancing troops to gain their bearings.

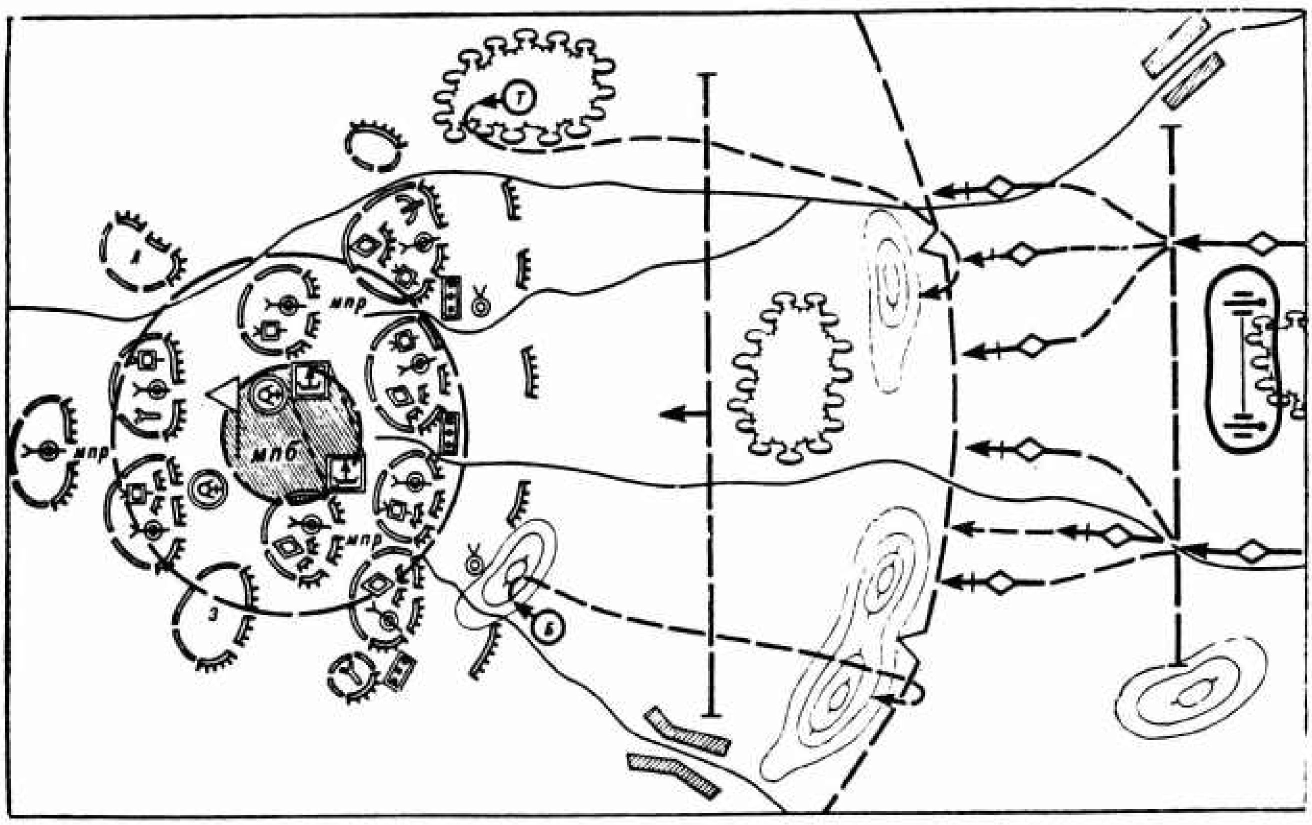


Figure 6.1.2. Safety Procedures When Delivering a Nuclear Strike During a Subunit Attack Without a Halt in Attack Position (Variant)

Key:

мпб -- motorized infantry battalion

мпр -- motorized infantry company

Under these conditions, when assigning missions to subunit commanders and vehicle crews, it is necessary to indicate stable landmarks, the potential character of terrain change, and to specify measures to provide comprehensive and timely support of the tank advance.

Advancing tanks should themselves reconnoiter routes for bypassing physical destruction and tree blowdowns, conduct radiological reconnaissance, and should cross blowdown and physical destruction areas with their own resources and without a halt.

Chapter 2. TANKS AGAINST ANTITANK WEAPONS

Antitank weapons which can be aggressively employed against tanks include the following: tactical and operational-tactical nuclear weapons, aircraft, artillery, enemy tanks, engineer troops antitank weapons, as well as ground troops antitank weapons, particularly antitank guided missiles (ATGM).

The experience of the war in Vietnam and particularly in the Near East demonstrated convincingly that ATGM are the most effective of all the above listed weapons, disregarding nuclear weapons. Therefore in this chapter, following a brief review of antitank weapons, principal attention will be focused on tank combat against ATGM.

1. Possible Actions Against Tanks

Foreign military experts believe that in conditions where there is no close contact between the opposing sides, tanks may be subjected to attack by tactical nuclear weapons, aircraft, and ground troops.

In their opinion, tactical nuclear weapons can be employed against hostile tanks at a considerable distance. Experiments conducted abroad have indicated, however, that employment of medium yield nuclear warheads (10-100 kt) against tank forces is little effective without precise information on their location. The results of employment of nuclear weapons will also be relatively limited when employed against already dispersed enemy combat formations. It is considered in the foreign military press that employment of nuclear weapons usually produces the greatest effect against already engaged units, the location of which is precisely known.

It is stated in the foreign literature that aircraft, in addition to bombing lines of communication, with the objective of impeding the movement of hostile mechanized and tank troops and disrupting their logistical support, should kill even well-protected tanks with direct fire. Aircraft are armed specifically for this mission with missiles carrying a shaped-charge warhead.

It is noted that in combat, due to complexity of control, one cannot count on air support in engaging tanks. Therefore the foreign military press expresses the view that ground troops should employ primarily helicopters to combat tanks; helicopters, working in coordination with a ground force, supplement and increase the capabilities of other antitank weapons. Since helicopters are vulnerable to antiaircraft weapons, however, they should skillfully utilize terrain

irregularities for concealment and fire their ordnance from a standoff distance, remaining beyond the range of hostile light antiaircraft weapons.

It is believed that joint actions by helicopter gunships and tanks or tank destroyers increase the effectiveness of each of these weapons. A helicopter's radius of action and speed enable the command to concentrate a large number of helicopters in a tank massing area and to shift them to another area in a relatively short period of time. A sufficient number of helicopters armed with missiles can change the course of battle. At the present time helicopters are armed chiefly with manually controlled ATGM (type SS-11). They have a range of 3,000 meters. Work is in progress on increasing the range and effectiveness of these missiles.

Great Britain, the FRG, France and the United States developed the Swingfire, HOT and TOW antitank missiles. The French-West German HOT ATGM is presently the only one with an effective range of 4,000 meters. It is believed that this promising missile will become the principal helicopter weapon.

Artillery in turn can deliver fire on tanks the location of which is known. In the opinion of Western military experts, however, artillery rounds are currently poorly suited for engaging tanks. The French 155 mm fragmentation shell, for example, possesses sufficient penetrative power, but it too has proven little effective.

Attempts are presently in progress abroad to develop cluster rounds. These projectiles, bursting in the air above tanks, scatter warheads which damage the tanks. It is noted that this solution to the problem of engagement of tanks is more suitable for rocket projectiles fired by salvo-fire rocket systems. Efforts are in progress to fit tactical missiles with antitank warheads. Each warhead contains a shaped charge and heat-seeking head, which seeks out, locks onto and destroys a tank on the battlefield.

It is believed that tanks which are widely scattered over the terrain (which is essential in combat with threatened employment of nuclear weapons) are a poor target for field artillery, requiring an excessive expenditure of ammunition. Approximately 10 tons of ammunition must be expended in order to destroy with a 50 percent probability half of a subunit consisting of 10 tanks dispersed over an area of 0.2 km^2.*

It is believed that in combat with enemy tanks and mechanized forces, the principal role will be played by tank and mechanized units; crews of self-propelled antitank guns or missile launchers will also be involved, and helicopter gunships will have greater importance.

Special tank destroyer companies have been established in FRG brigades to combat tanks.

France has not taken the path of building heavy self-propelled antitank guns but has opted for a light tank (tank destroyer), following the concept of "maximum firepower with minimum tank weight."

* See [Zh. Marzloff], "Combating Tanks," REVUE MILITAIRE GENERALE, July 1972.

In order to improve the AMX-13 tank, a 90 mm gun was mounted on it, and subsequently a 105 mm gun. Thus a fairly effective weapon was developed for combating tanks at medium ranges. France has also launchers armed with Harpoon ATGM, with a semi-automatic guidance system.

As already noted, there is presently going on a debate abroad on whether to arm a tank with a gun or antitank missiles.

It is noted that the most modern of the ATGM being developed, the Acra, travels at a speed of 520 mps, that is, two or three times slower than antitank artillery shells. A gun is more convenient, since in combat speed of actions and accuracy of fire are of primary significance.

A gun mounted on a heavy tank can be highly accurate at ranges up to 3,000 meters. The gun on the AMX-30 tank, for example, is almost sure to hit any stationary target at a range of 2,800 meters if range to target has been accurately measured with a laser rangefinder.

When firing at moving targets and in unfavorable conditions (in a strong wind), however, the target hit probability of an antitank missile is greater than that of an artillery shell. The difference in these probabilities increases with an increase in range to target. Thus it is believed that while the gun is the best armament for a tank, the missile should be the principal antitank weapon. In direct fire positions ATGM and antitank guns will supplement one another. According to foreign data, an ATGM is 15-20 times more expensive than a modern antitank artillery shell, and therefore it is recommended to be employed when really necessary. Engineer subunits can also combat tanks. They possess effective antitank weapons -- landmines of various modifications. French side armor penetration mines, which can penetrate 75 mm of armor within a radius of 40 meters, are effective, for example. These mines are difficult to detect, since they are made of non-metallic components. It is stated in the foreign literature that although these measures against tanks do not inflict heavy tank losses on the enemy, they do slow their advance.

In close combat tanks are also engaged by other ground troops antitank weapons. Infantry play a special role in this. But the main thing is that all subunits and units -- artillery, engineer, combat service, etc -- are armed with antitank weapons enabling them to engage tanks in close contact.

It is believed that troops should be armed with light, man-portable weapons which are sufficiently effective against the heaviest tanks and which boast a high accuracy of fire at considerable range. Existing antitank weapons are subdivided into individual and crew-served.

Individual antitank weapons include light grenade launchers and antitank rocket launchers, such as the M72 (United States), ARPAC and SARPAC (France).

Crew-served antitank weapons usually are assigned to squads or platoons. They include antitank rocket launchers, the range of which has increased to several hundred meters as equipment has improved. The armies of many countries would like to have antitank rocket launchers with an effective range of 1,000 meters. The range of modern crew-served weapons can exceed 300 meters (the F-1 STRIM antitank rocket launcher) and can be as much as 500 meters (APX-80).

Advances in rocketry make it possible to consider some ATGM today also as individu:_ weapons. For example, the MILAN ATGM can be included in this group. Two men can easily carry it with two rounds a fairly substantial distance. When ATGM are employed as individual weapons, effective range increases from 300-500 m to almost 2,000 m. It is believed that the MILAN ATGM will replace crew-served weapons -- recoilless guns and ATGM of the preceding generation. Such an ATGM can also be mounted on infantry combat vehicles, which will kill tanks at a range of up to 2,000 meters.

Foreign experts conclude that principal attention in the area of antitank weapons is being focused on increasing rate and accuracy of fire at targets at any range. Efforts are not restricted to development solely of heavy weapons. Light antitank weapons today have a range of up to several hundred meters. Attention is also devoted to small-caliber automatic antitank guns, which are a fairly effective means of combating light tanks.

In the French Army, for example, there are actually no special antitank units and subunits, with the exception of AMX-13 tank platoons, ATGM subunits of mechanized regiments, and ground forces light aviation helicopter gunship sections. In each mechanized platoon squad, in addition to antitank mines and grenades, there is an F-1 STRIM antitank rocket launcher or two MILAN ATGM, which can be fired either from the ground or from the AMX-10P vehicle.

The shaped charge is the basis of the majority of antitank rounds. It is believed that, proceeding from current conditions, ATGM will evidently be employed against targets at medium and long ranges. It is recommended that helicopters be utilized for this. Therefore Alouette helicopters are being armed with SS-11 and other antitank missiles.

In the ground forces of the FRG, divisions and army corps do not have independent antitank subunits, although the army corps tank regiment is viewed as a reserve for combat against tanks. Tank and motorized infantry brigades contain tank destroyer companies armed with antitank guns and missiles. Infantry (jaeger) battalions contain heavy weapon companies armed with weapons for combating tanks. Antitank weapons at various echelons of combined-arms units include the Energa 75 mm rifle grenade, the Panzerfaust 44 mm antitank rocket launcher, the Karl Gustav 84 mm antitank rocket launcher, the Cobra or SS-11 ATGM, as well as 90 mm self-propelled and auxiliary-propelled antitank guns.

In the ground forces of Great Britain, the principal antitank weapons include the Wombat 120 mm recoilless gun, the Vigilant ATGM (or Swingfire ATGM), the Karl Gustav antitank rocket launcher, Rarden 30 mm antitank guns mounted on FV432 Trojan armored personnel carriers, and Energa rifle grenades.

In armored cavalry reconnaissance regiments, 15 out of 45 Ferret armored cars are armed with Vigilant ATGM. Eight out of 11 tank battalions contain platoons of FV432 Trojan armored personnel carriers armed with Swingfire ATGM.

The question of employment of helicopters to combat tanks occupies the attention focus of experts.

Primary significance is also attached to combat against tanks in the U.S. Army. In the army corps, an armored division contains M60 main battle tanks of various modifications, and M551 Sheridan light tanks. Airmobile companies contain helicopter gunship sections. In the division, the tank battalion is the principal element of organization of antitank defense.

Motorized infantry and infantry units are armed with 90 mm recoilless guns. Fire support companies are armed with 106 mm recoilless guns, while some have TOW ATGM. The 66 mm grenade launcher is an individual antitank weapon. Airmobile units are armed with 90 mm guns, 40 mm grenade launchers, and ATGM (SS-11, TOW).

Thus it is believed that ATGM are the principal means of combating tanks.

2. Modern Antitank Guided Missiles (ATGM) and Their Influence on Tank Operations

The war in the Near East demonstrated the great effectiveness of ATGM: seven out of every 10 tank kills were by ATGM. In connection with this, foreign military experts reached the conclusion that in order for the tank to be able to dominate the battlefield in future wars, it must possess a high degree of survivability and be capable of successfully combating a new and formidable adversary -- the antitank guided missile.

The development of ATGM gave rise in some foreign military experts to doubt about the advisability of employing tanks in modern warfare. Even opinions to the effect that the tank is no longer viable were expressed. Practical experience and the events of recent years, however, have refuted these forecasts.

We know from past experience that when a new weapon has appeared, no matter how formidable, there has always been found a weapon to localize it or to reduce its effectiveness to a minimum.

It is believed abroad that this has also occurred with regard to the ATGM. At first, in proving ground tests and at the first stage of the war in the Near East, they seemed truly omnipotent, capable of changing the role of tanks on the battlefield. But a subsequent thorough study demonstrated that such a conclusion was premature. The new weapons contain deficiencies which enable tanks to operate successfully. And just as war chariots, beginning with the time of Alexander the Great, inspired terror in the infantry and cavalry phalanxes, modern tanks will continue for many years to come to maintain absolute domination of future battlefields. In order to see this, one must analyze the capabilities of ATGM and methods of combating them.

A brief analysis of modern ATGM will elucidate their positive and negative characteristics. Table 6.2.1 lists antitank guided missiles presently operational and under development in the most highly equipped foreign armies, and their performance characteristics.

Foreign military experts subdivide ATGM into three generations, based on guidance system and period of development, as well as when they became operational: first, second, and third generation.

At the present time the ground forces of the NATO armies are armed with first-generation ATGM, which became operational at the end of the 1950's and beginning of the 1950's, and improved second-generation ATGM, which became operational at the end of the 1960's and beginning of the 1970's.

First-generation ATGM are characterized by a manual guidance system. They include the Vigilant, Cobra, and ENTAC light ATGM, with a range of 1,400-2,000 meters, the heavy SS-10, SS-11, and SS-12, with a range of 3,500-6,000 m, plus others. One feature of these ATGM is guidance by the "three points" method and the existence of a large safe zone -- 200-500 m. Foreign military experts note that this is a major drawback of first-generation ATGM.

In the opinion of these experts, positive aspects of first-generation ATGM include a high degree of effectiveness of fire (mean target hit probability 0.75-0.8) and 530-700 mm armor penetration.

Second-generation ATGM have a semiautomatic guidance system, which made it possible substantially to increase ATGM maximum speed (to 300-850 mps) and target hit probability to 0.8-0.9 and more (to 0.94-0.99 for the Shillelagh ATGM).

Second-generation ATGM are subdivided, in conformity with the NATO classification, into two groups: light (man-carried) missiles with a range up to 2,000 m (MILAN, Dragon), and heavy (vehicle-carried) missiles (TOW, Shillelagh, HOT, SS-11B1), with a range to 4,000 meters and more. The safe zone of the second-generation ATGM sharply decreased -- to 25-75 and 200-300 meters.

Launchers for the majority of heavy ATGM are mounted on an armored chassis (APC, ICV, tanks), as well as on helicopters and fixed-wing aircraft.

According to figures in the foreign press, second-generation ATGM will be in service with NATO forces up to the middle of the 1980's, after which they will be replaced by third-generation ATGM.

Third-generation ATGM, as foreign experts note, will be characterized by improved guidance systems, high speed, light weight and small size. Semiactive homing guidance heads and laser target illumination will increase their combat effectiveness and provide capability to deliver fire on a target when the launcher is both in a direct and indirect fire position. It is anticipated that third-generation ATGM will begin to become operational in NATO nation armies by 1980.

It is evident from Table 6.2.1 that ATGM in service can penetrate armor 400-700 mm in thickness. Such effectiveness is due to the fact that all ATGM are designed according to the principle of utilizing a shaped-charge jet of gases of highly-effective explosives possessing a high temperature, high velocity, and enormous pressure at the focus of the jet. As has been reported in the foreign press, armor piercing capability of ATGM presently under development will be not less than the figures specified in the table. Thus, as regards armor defeating performance, ATGM are extremely dangerous to tanks, and therefore, it is believed abroad, increasing tank survivability should be achieved primarily by increasing tank armor resistance to shaped-charge projectiles and diminishing the shaped-charge effect of antitank guided missiles.

Performance Characteristics of ATGM of Foreign Armies

Table 6.2.1

ATGM Designation	Country Where in Service	Guidance System (In-Flight Guidance)	Weight, kg, of Missile (Warhead) / System	Range of Fire, m Maximum / Minimum	Thickness of Armor Piercing Capability, mm / Maximum Speed m/s	Length, mm / Diameter (Size of Stabilizer), mm	Launcher Location
1	2	3	4	5	6	7	8
		First Generation					
SS-10	France (1955), no longer produced	Manual, wire-guided	15(5) / .	1600 / 300	500 / 80	860 / 164(750)	Armored cars, light tanks
SS-11	France (1958), series production; NATO countries	Manual, wire-guided (aerodynamic)	28.4(6) / 30	3500 / 500	600 / 190	1160 / 164(500)	Portable launchers, launchers mounted on trailers, trucks, APC, tanks, helicopters, fixed-wing aircraft
SS-12	France (1965), series production; NATO countries	Manual, wire-guided (jet vanes)	75(3) / .	6000 / 800	600—700 / 240	1870 / 210(650)	Trucks, APC, helicopters, patrol craft
Vigilant 897, Vigilant 889	Great Britain (1961, 1962), series production	Manual, wire-guided (dynamic)	14(6) / 25	1400 / 185—275	600 / 156	1070 / 110(280)	Mobile launchers, armored cars, helicopters (launcher tube is used as transport container)
Swingfire	Great Britain (1969), series production	Semiautomatic, wire-guided (swiveling nozzle)	26(7) / .	4000 / 150	530 / 185	1067 / 170(370)	Portable launchers, tanks, APC, armored cars, helicopters
T581 ENTAC	France (1960), series production; NATO countries (1961)	Manual, wire-guided (spoilers)	12(5) / 17	2000 / 400	500 / 85	830 / 150(370)	Portable launchers, launchers on trucks and APC (launcher serves as transport container)
Cobra 810B, Cobra 2000	FRG (1962, 1968), series production	Manual, wire-guided (spoilers)	10(2.5) / .	1600, 2000 / 400	500 / 85	950 / 100(480)	Portable launcher (can be mounted on vehicles)

Table 6.2.1 (cont'd)

1	2	3	4	5	6	7	8
Malcara Mk1A	Great Britain (1959), production terminated	Manual, wire-guided (aerodynamic)	97(27) / .	3200 / 450	500 / 130	1970 / 225(790)	Hornet, Humber twin launcher, M113 APC, twin launcher on M59 APC chassis, helicopters
		Second Generation					
Shillelagh Mk2	United States (1966), series production	Semiautomatic, with infrared command transmission link (jet nozzles)	27(6,2) / .	3000 / 200	600 / 287	1150 / 152(280)	M551 Sheridan and M60A2 tanks
Shillelagh Mk 3	United States	Semiautomatic, infrared communication channel	. / .	4000 / 300	600 / .	1150 / 152(280)	Same
TOW	United States (1968), series production; FRG (1971), purchase	Semiautomatic, infrared guidance channel	17(3,6) / 91	3750 / 65	500 / 210	1140 / 148(415)	Portable launchers (tripod-mounted launcher), self-propelled launchers mounted on APC and trucks
Dragon	United States (1972), tests, preparation for production	Semiautomatic infrared, wire-guided (pulse jet)	6(2,5) / 14,5	1000 / 30	430 / 110	650 / 123(320)	Portable launchers (launcher tube used as transport container)
SS-11B1	France (1965), series production; NATO countries	Semiautomatic infrared, wire-guided (aerodynamic)	29(6) / .	3000 / 350	600 / 190	1200 / 164(500)	Twin launchers on APC, trucks, helicopters, tanks
MILAN	France, FRG (1974)	Semiautomatic infrared, wire-guided (jet vanes)	6,6(2,9) / 27	2000 / 25	500 / 200	769 / 130(260)	Launcher (tube-carrier container on mount) can be mounted on vehicles
HOT	France, FRG (1973)	Semiautomatic, infrared, wire-guided (jet vanes)	22(6) / .	4000 / 75	550 / 260	1270 / 132(310)	Launchers on APC, helicopters, tanks, ICV

Table 6.2.1 (cont'd)

1	2	3	4	5	6	7	8
		Experimental ATGM and In Development (Third Generation)					
Atlas	Great Britain and Belgium (Experimental)	Semiactive head, homing guidance with laser-illuminated target	. / .	1000 / 15	400 / 220	. / 110	Portable launcher
Acra	France (1975)	Semiautomatic, laser beam (aerodynamic)	24(7) / .	3300 / 25	600 / 520	1200 / 142(130)	AMX-63 tank, AMX-10C APC
Mamba	FRG	Manual, wire-guided (spoilers)	11.2 / .	2000 / 300	500 / 140	995 / (400)	Launch gear same as Cobra ATGM
Mystic	United States	Semiautomatic, with homing guidance head and laser illumination of target	11.2 / .	6000 / .	500 / .	995 / 152(177)	Portable launcher
LASH	United States	Semiautomatic, laser guidance	. / .	1500 / 25	500 / 550	more than 300	AMX-63 tank, APC
Sparviero	Italy	Semiautomatic, infrared beam	. / .	4000 / 75	. / 290	. / 130	Portable launcher
Diano	Italy	Semiautomatic, radio	. / .	3500 / 75	500 / 475	. / .	Portable launcher
Polecat	United States	Semiautomatic, homing guidance, infrared target illumination	. / .	1830 / .	. / .	. / 120	Antitank or recoilless gun
Hornet	United States	Semiautomatic, homing, laser target illumination	. / .	. / .	. / .	. / 177.8	Same
Hellfire	United States	Semiactive laser	27.2 / .	5500 / .	. / .	1500 / 152	Helicopters

At the present time there is observed abroad a trend toward decreasing the weight of ATGM and toward their miniaturization. For example, while the earliest ATGM, such as the Malcara, SS-12 and others weighed between 75 and 100 kg, the weight of modern ATGM in service and under development will be 6-30 kg (Dragon, TOW, ACRA). In connection with a decrease in weight, there has also been a decrease in the size of antitank guided missiles. This has led to the employment of a large number of ATGM on launchers mounted on trucks, armored personnel carriers, tanks, fixed-wing and rotary-wing aircraft. The foreign press notes a trend toward increase in the ATGM basic load of ammunition in antitank subunits.

There is a trend toward increasing the flight speed of ATGM, since it is obvious to everybody that the greater a projectile's speed, the less time a tank has to maneuver and take shelter behind terrain irregularities or local features, and therefore the greater its vulnerability. An analysis indicates that while the majority of antitank guided missiles presently in service and in production travel at a maximum speed of 80-85 m/s (SS-10, ENTAC, Cobra 810B, Cobra 2000, MAT, Bantam) or range between 110 and 260 mps (SS-11, Dragon, Vigilant, Malcara), second-generation missiles in production or under development have a maximum speed of 270-650 mps (Swingfire, HOT, ACRA, Mosquito). One should bear in mind that knowledge of range of fire against tanks is acquiring great significance for developing tank tactics in conditions of enemy employment of ATGM.

We know that two ranges are specified with ATGM: minimum and maximum. Minimum range is the distance from the ATGM launcher to the point where a fired missile becomes guided. Maximum range is the range of missile flight during which it remains guided. For the majority of ATGM in service, minimum range varies from 300 to 500 meters, and maximum range from 1,500 to 4,000 meters. Some foreign ATGM, however, have a minimum range of 25-200 meters and a maximum range up to 6,000 meters (SS-12).

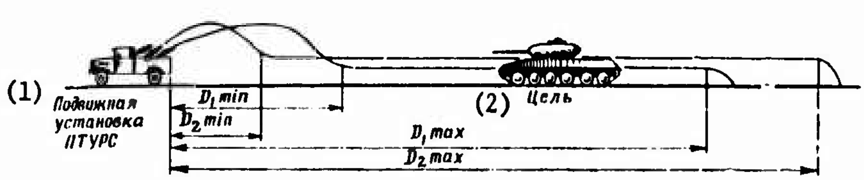


Figure 6.2.1. ATGM Minimum and Maximum Range of Fire

Key:
1. Mobile ATGM launcher
2. Target

D_1 -- First generation
D_2 -- Second generation

As is evident from Figure 6.2.1, at minimum range a missile is not yet guided and a tank enters a "dead" zone, as it were, in which it cannot be hit. Foreign military experts believe that this circumstance should be taken into consideration in developing tactics for tanks attacking ATGM positions. Tanks, taking advantage of terrain irregularities and local features, should get into the ATGM "dead" zone as quickly as possible and from this zone destroy the antitank guided missile positions with their fire or tracks.

The foreign military press notes that the commencement of a missile's guided flight depends in large measure on the skill and ability of the firer (operator): the less well-trained the firer (operator), the larger the ATGM "dead" zone will be.*

It is also noted that knowledge of the maximum range of ATGM enables one correctly to select tank deployment lines beyond the zone of effective ATGM fire. In those cases where terrain is flat and open, according to foreign sources, it is recommended that the tank deployment line be specified not closer than the maximum range of ATGM fire.

Saturation of combat formations with ATGM, as well as their improvement and provision of the capability of firing ATGM from man-portable and mobile launchers, have substantially complicated tank actions on the battlefield.

We know that ATGM in service with NATO armies are launched from ground or mobile launchers, including tanks, armored personnel carriers, infantry combat vehicles, fixed-wing and rotary-wing aircraft. Missiles are fired either directly from their transport containers or from special launching devices with guides and mounted on vehicles. Figure 6.2.2 and 6.2.3 show methods of launching ATGM.

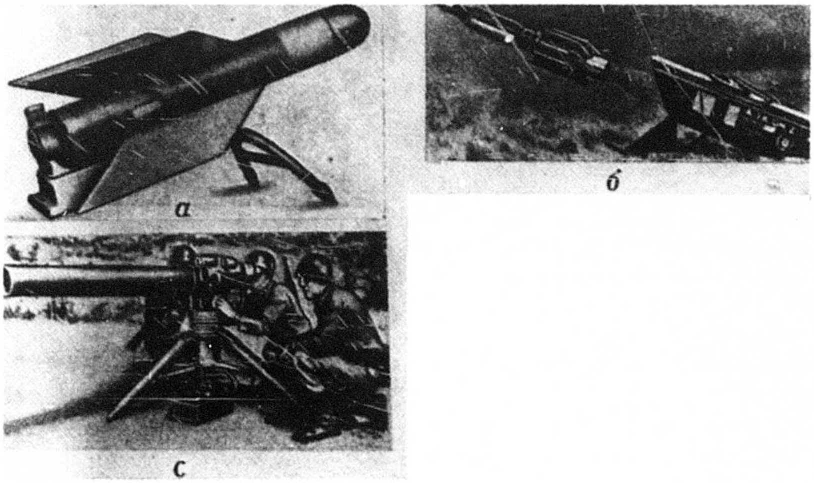


Figure 6.2.2. Methods of Launching ATGM from Stationary Ground Launchers:

a -- from ground launcher; b -- from transport container; c -- from launch tube

---

The majority of new ATGM presently on the drawing board are to be fired from a tube mounted on a special tripod. A missile can also be fired from a shoulder-held tube (MILAN, HOT, TOW). Foreign military experts believe that knowledge of missile guidance systems is acquiring great importance for development of tactics of combating ATGM. Basically there can be many different systems of guiding ATGM to the target. At the present time, however, following are the principal missile guidance systems employed in the armies of capitalist countries**:

* See REVUE MILITAIRE GENERALE, July 1972.

** See TRUPPENDIENST, May-June 1972; REVUE MILITAIRE GENERALE, July 1972.

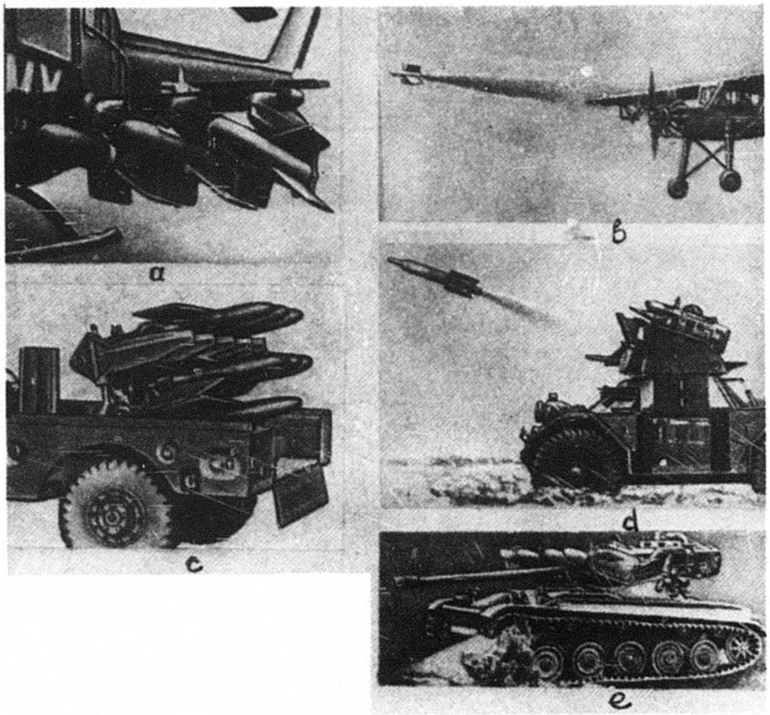


Figure 6.2.3. Methods of Launching ATGM from Mobile Launchers:

a -- from helicopter; b -- from fixed-wing aircraft; c -- from truck; d -- from armored personnel carrier; e -- from tank

---

a) manual -- remote control with commands transmitted by wire or radio;

b) semiautomatic or combination -- wire guidance plus homing head employing infrared or UHF beams, as well as laser beam;

c) self-contained or automatic.

It is pointed out that all guidance systems other than an automatic system involve manual guidance and require a controller (operator), who must guide the missile's flight, from launch to target impact.

In manual ATGM guidance systems (SS-10, SS-12, Vigilant, Swingfire, Cobra, Malcara), the operator must constantly track the target and the missile in flight and steer it into the target by means of a control device, with the aid of which commands are transmitted to the missile by wire or radio. The commands "Right," "Left," "Down," and "Up" are sent to the missile. Superimposing the target and missile onto a single point, the operator steers the missile to the target. Thus in manual or command guidance systems there are three communication links which can be affected in order to prevent a tank from being hit: the weapon-target line, the missile trajectory, and communication channels for transmitting commands from operator to missile (wires or radio channels).

It is noted that in combination or semiautomatic guidance systems (MILAN, HOT, Dragon, Shillelagh) the operator tracks only the target. The missile automatically tracks the operator-target line, seeks to go onto this line, and follows it into the target. In these systems there are only two communication links: operator-target line, and missile flight trajectory.

It is sufficient to exert effective influence on just one communication link in order to prevent a tank hit. Tankers should utilize precisely this in combating enemy ATGM.

In self-contained or automatic guidance systems, such as the Atlas, Mamba, and Hellfire ATGM, the missile guides itself to the target. Therefore these systems contain only one communication link which must be acted upon in order to complicate or prevent a target hit.

In order better to understand the mechanism of missile guidance to the target, we shall examine the semiautomatic guidance system employed by the French second-generation SS-11B1 ATGM.*

Figure 6.2.4 contains a block diagram of this missile's semiautomatic guidance system. It operates as follows. The operator spots a mobile armored target with the aid of an optical instrument which is rigidly connected to the infrared guidance system sensor and, holding the target in the instrument's crosshairs, fires the missile. The semiautomatic guidance system commences to function as soon as the missile is fired.

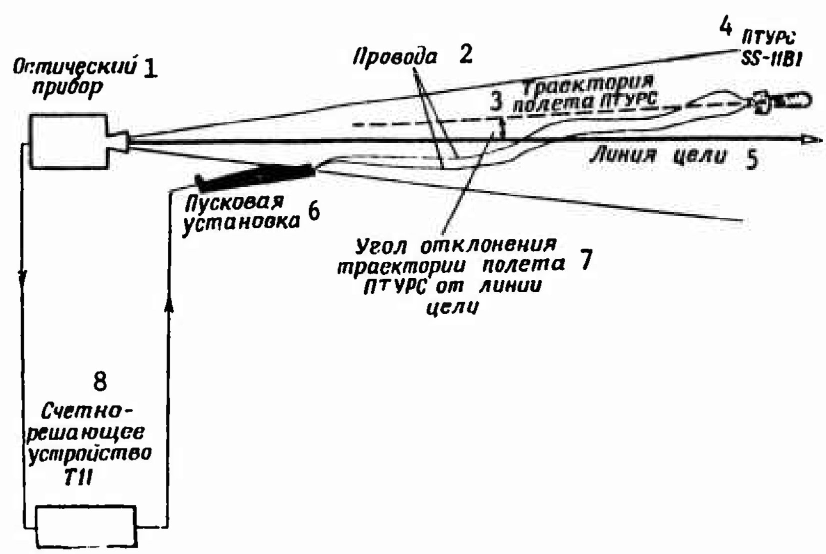


Figure 6.2.4. Block Diagram of a Semiautomatic ATGM Guidance System

Key:
1. Optical instrument
2. Wires

* See REVUE MILITAIRE GENERALE, July 1972.

Key to Figure 6.2.4 (cont'd)

3. ATGM trajectory
4. SS-11B1 ATGM
5. Operator-target line
6. Launcher
7. Angle of deviation of ATGM trajectory from operator-target line
8. T11 computer

The system's equipment, which detects the infrared radiation of the tracking flare on the missile in flight, automatically holds the missile on the operator-target line. If the missile deviates from the line to target, data on the deviation angle are fed into a computer (T11) hooked up to the launcher, and the computer generates appropriate commands in the form of electrical pulses transmitted by wire to the missile. These commands are transformed in the missile's onboard equipment into corresponding movement of the missile's controls, as a result of which it returns to the operator-target line.

Analysis of existing foreign guidance systems indicates that manual guidance of the missile to the target is essential in the majority of these systems. Many Western military experts note this as a shortcoming of ATGM. General [Zh. Marzloff], for example, notes in an article entitled "Combat Against Tanks"* that during firing of an ATGM the controller-operator must the entire time track either the target and missile simultaneously or just the target. If he loses sight of the target or missile for several seconds, the ATGM may go astray. This is a very important factor for organization of countermeasures against antitank guided missiles and, in the opinion of foreign military experts,** generates a number of attractive ideas for tank actions upon encountering an ATGM.

3. Methods of Tank Protection From and Countermeasures Against ATGM

In view of the combat capabilities of ATGM and a trend toward heavily saturating troop combat formations with them, tankers should consider them enemy number one and possess the skill of combating them effectively. This is possible if one knows their strong and weak points.

Foreign military experts consider the following to be the strong points of ATGM (Table 6.2.1):

capability to pierce the thickest armor which tanks can carry -- 400-650 mm;

versatile launch capability from ground and mobile launchers, including armored vehicles, fixed-wing and rotary-wing aircraft;

high battlefield maneuverability and simplicity of operation;

battlefield utilization capability against all targets;

* See REVUE MILITAIRE GENERALE, July 1972.
** See TRUPPENPRAXIS, February 1977.

high moving target kill probability: 95 percent at maximum range, and 85 percent at minimum range.*

Foreign military experts note the following as weak points of ATGM**:

the necessity of continuously tracking target and missile with manual (command) guidance systems and only the target with semiautomatic guidance;

brief loss of the target from sight, which can result in the missile going astray;

considerable missile flight time to target;

increased number of missile guidance failures as the missile proper becomes more complex;

existence of a "dead" zone to a distance of 300-500 meters from the launcher.

Proceeding from an evaluation of the strong and weak points of ATGM, three modes of protection of tanks and countermeasures against ATGM are noted: group, individual, active, and passive.

With the group method of protecting tanks and countermeasures against ATGM, measures providing protection of the tanks of the entire attacking or defending subunit, as well as destroying or neutralizing hostile ATGM are conducted in a centralized manner, by orders of the senior commander.

One of the most effective group methods of protecting tanks from and countermeasures against ATGM is tank employment of tactics which make it difficult for the adversary to employ ATGM. Such tactics include utilization by tank subunits of terrain conditions (ravines, gullies, woods, copses, inhabited localities, standing crops, and brush) for closing with the enemy and simultaneous neutralization of ATGM launcher positions with artillery fire or airstrikes. The longer the time during which tanks remain unseen by enemy ATGM operators during closing to contact and assault, the greater the tanks' chances of survival.

Utilization by tanks of rough terrain covered by brush, sparse trees or local features can lead to premature detonation of ATGM if the warhead fuzes are set for instantaneous, or to loss of guidance as a consequence of breaking of command transmission wires from control box to missile. Figure 6.2.5 demonstrates the principle of utilization of terrain irregularities and local features for tanks closing with and neutralizing ATGM.

Neutralization of ATGM launcher positions with nuclear weapons, massed artillery fire and airstrikes, as well as fire delivered by the attacking tank subunits, as noted in the foreign military press, is also a group method of protecting tanks from and countermeasures against ATGM. It was noted above that in order to score a tank hit, ATGM controller-operators must continuously maintain visual contact

* ZARUBEZHNOYE VOYENNOYE OBOZRENIYE, Moscow, No 9, 1978.
** See ORDNANCE, September-October 1972.

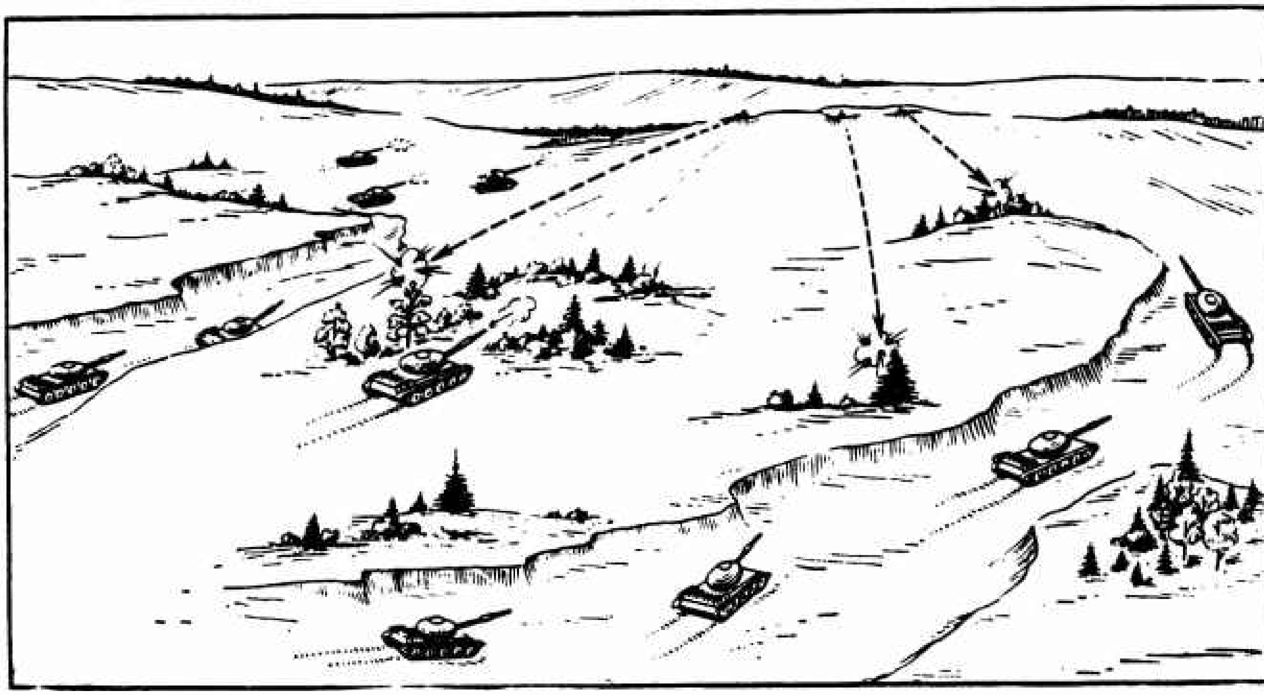


Figure 6.2.5. Utilization of Terrain Irregularities and Local Features for Tanks to Advance to and Attack an ATGM Launcher Position

with the target in their guidance instruments. If the tracker turns his head away for a few seconds, he will lose the missile. Nuclear bursts as well as airstrikes, and heavy artillery and mortar fire will force operators to seek brief shelter, and consequently lose their target (Figure 6.2.6).

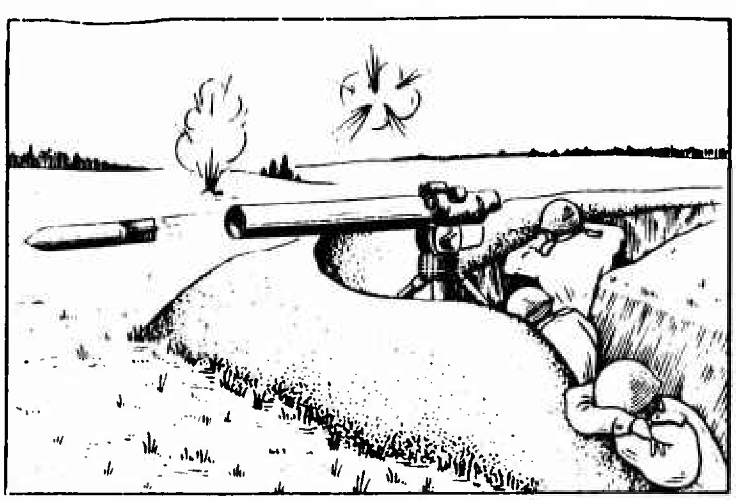


Figure 6.2.6. Artillery Fire and Airstrike Countermeasures Against ATGM

Many foreign theorists believe that laying down smoke screens by aircraft, with the aid of artillery and the tanks themselves, also constitute a means of group protection of tanks. The appearance of a solid or limited-area smoke screen forward of ATGM launcher positions will cause controller-operators to lose sight of the targets, and consequently lose their missiles as well. Employment of smoke screens on open terrain with sparse vegetation will be one of the principal means of group protection of tanks. Figure 6.2.7 shows a method of group protection of tanks by laying smoke screens. Smoke screens can be employed, however, only in conditions where the wind is blowing in the direction of enemy ATGM positions or at a certain angle to them.

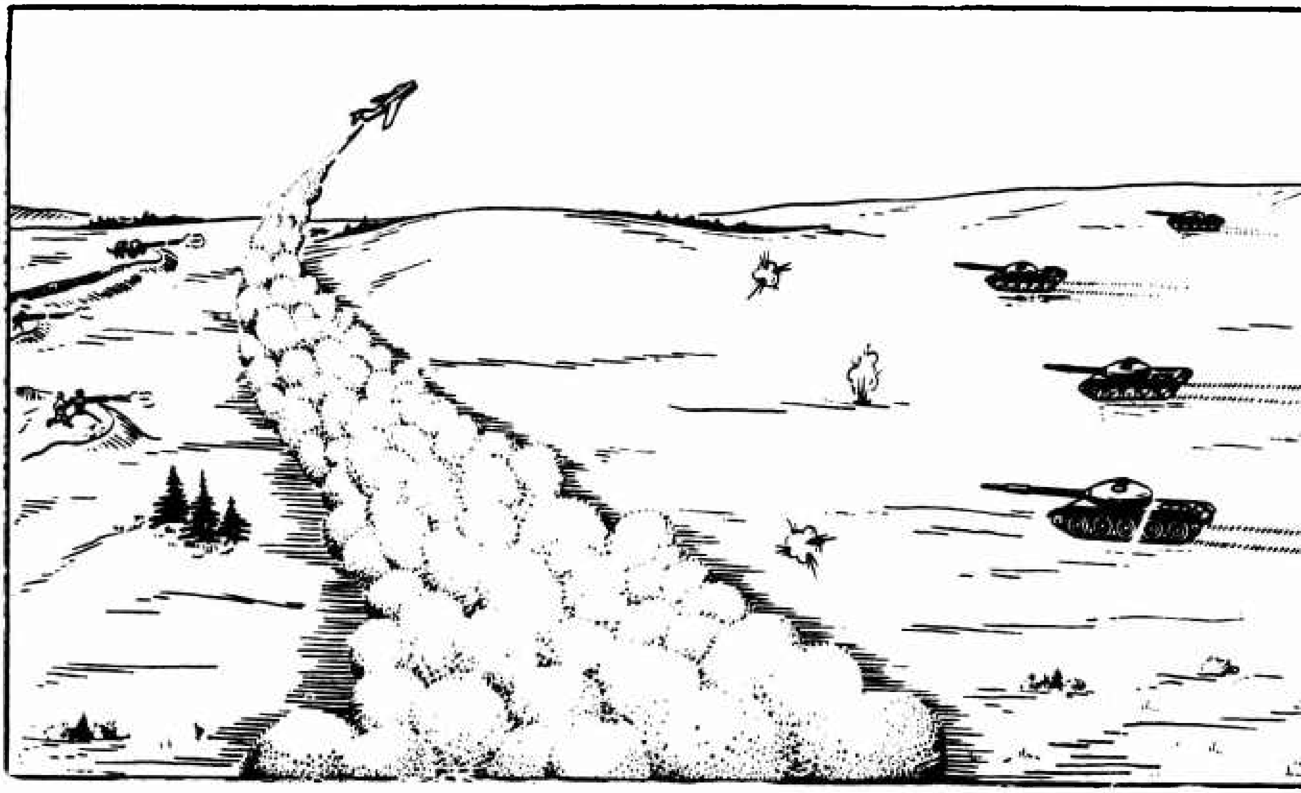


Figure 6.2.7. Method of Group Protection of Tanks From ATGM Fire by Laying a Smoke Screen

The opinion is expressed in the foreign press that jamming radio command missile guidance systems and employment of decoy targets to fool homing-guidance missiles can be a group method of protecting tanks from and countermeasures against ATGM.*

The opinion is also expressed, however, that with properly organized ATGM radio command guidance, jamming is extremely difficult. For example, the controls of second and third-generation ATGM (TOW, MILAN, HOT, ACRA, Hellfire) can operate in the 1-meter, decimeter, and centimeter bands. Therefore jamming must cover a

* See ORDNANCE, September-October 1972.

broad range of frequencies. And this requires radio and radar jamming transmitters with an output of not less than 250 kw. Such jammers can be carried on armored vehicles proceeding in the combat formations of tanks, or on board aircraft escorting the attacking tanks.

It is recommended that false radar targets be generated during a tank attack, which can also perform the role of group protection of tanks. False radar targets, such as corner and other reflectors, metal strips, etc, can be generated by specially assigned armored vehicles proceeding ahead of the attacking tanks, as well as from the air by fixed-wing and rotary-wing aircraft.

As regards homing missiles (ACRA, Mystic, Hellfire ATGM), in these instances it is recommended that one consider the fact that their homing heads commence operating fairly close to the target -- 100-150 m. And this means that there will be very little time available for jamming such missiles, and therefore protective measures must be undertaken by bounds, in a centralized manner, in the course of the attack. Foreign experts consider passive protection measures to include scattering of napalm flame generators or extended-flight flares by patrol and reconnaissance tanks or with the aid of fixed-wing and rotary-wing aircraft on lines which tanks will be crossing, as well as utilization of special tanks to generate protective smoke screens forward and on the flanks of attacking tanks.

Stated in the foreign military literature is the idea of employing powerful searchlights to generate infrared screens forward and on the flanks of attacking tanks to protect them against ATGM with infrared heat-seeking heads. It is believed that employment of such searchlights can be very effective.

With the individual mode of protection and countermeasures, each tank protects itself and conducts countermeasures against hostile ATGM independently. Each tank crew performs various measures, which foreign experts list as follows: employment of smoke shells, generators and bombs by individual tanks; camouflage and concealment of combat vehicles, utilization of active tank protection by destroying ATGM in the field, as well as increasing tank armor resistance to shaped-charge warheads in order to reduce the effect of ATGM on an armored vehicle. Efforts to increase armor resistance are being conducted in many countries.* Problems of resistance of armored hulls have been studied since the appearance of antitank artillery. Armor resistance to shaped-charge warheads, however, did not begin to be examined until the development of shaped charges. Armor resistance to shaped-charge warheads can be achieved, on the MBT 70 tank, for example, by developing composite armor which can withstand high specific pressures and high temperatures. Since a shaped-charge jet burns through armor, heat-resisting components are employed in composite armor, and skirting plates are employed to ensure armor resistance to shaped-charge warheads. Skirting plates can vary (thin armor plates and metal screens mounted on the tank hull, etc). In Great Britain and the FRG, for example, armor plates are extensively employed as tank skirting plates.** For example, turret skirting plates, etc can be installed.

---

* See J. Polk, "We Need a New Tank," ARMOR, July-August 1972.

** See [B. Dyunets], "Tank Gun or Guided Missile?" ORDNANCE, September-October 1972.

The purpose of employing skirting plates is to cause a shaped charge to burst prematurely, putting the tank's main armor beyond the focal point of the shaped-charge jet, where the pressure and temperature of the jet reach a maximum.*

Many foreign military experts believe that tank camouflage and concealment promotes their individual protection. Employment of camouflage makes a tank inconspicuous against the terrain background and thus makes it more difficult to detect and observe when firing an ATGM. In addition, employment of antiradar coatings on tank armor (M60A1) supposedly makes them little vulnerable to radar-homing missiles. This coating, applied under camouflage, makes visual and radar detection of tanks difficult.

Foreign experts also express the opinion that infrared camouflage is an important individual means of protecting tanks against missiles with infrared homing guidance. Armored vehicle infrared camouflage measures reduce the quantity of heat given off by an armored vehicle to the environment, and thus reduce the sensitivity of ATGM heat-seeking missiles. This, in the opinion of foreign military experts, makes difficult tank detection by antitank guided missiles, and homing guidance heads capture the target at close range, as a consequence of which ATGM will frequently overshoot the target. Displacing the thermal center to one side or above a vehicle may be an important means of individual protection of tanks against ATGM.** The displacement point should radiate considerable heat and offer a target to heat-seeking ATGM. The missile may hit only the heat release point, leaving the tank unharmed.

Finally, foreign military engineers believe that individual active protection of tanks by destroying ATGM on approach to the tank may be another significant measure.

In past wars shrapnel and canister shot development in artillery was no mere happenstance. If it was necessary to hit enemy infantry and cavalry close to friendly troops, canister shot or grapeshot was employed, while shrapnel was employed if this was to be accomplished at a distance from artillery positions. It is believed that this idea can also be successfully utilized for organizing countermeasures against antitank guided missiles as they approach tanks.

Western experts note that such individual means of active tank protection should include means of prompt and timely detection of hostile ATGM and should operate as self-contained automated systems. Without going into cost, but taking account of advances in radioelectronics and mechanics, they claim that such active means of individual tank protection can be developed.

We have examined above the group and individual modes of protecting tanks and countermeasures against ATGM, which differ in organization and extent of measures conducted. Both these modes in turn, however, can be active or passive in protection and countermeasures.***

---

* See ARMOR, July-August 1972.

** See H. Wein, "Antitank Defense at Night," TRUPPENDIENST, May-June 1972.

***See REVUE MILITAIRE GENERALE, July 1972; ARMOR, July-August 1972.

Active mode of protection and countermeasures is defined as neutralization and destruction of ATGM at principal launcher positions by airstrikes, artillery and tank fire, as well as by nuclear weapons, actively jamming ATGM guidance systems, and destroying ATGM during flight to the target with the aid of tank auxiliary or main armament.

Passive modes of protection are defined as those which diminish the effectiveness of ATGM. They include the following, according to data in the foreign press: employment of concealing or obscuring smoke screens, skirting plates and composite armor on tanks, and false targets to confuse homing-guidance missiles.

In conclusion we can state that the development of such antipodes as the tank and antitank missile once again confirms manifestation of the law of unity of opposites in military affairs. Improvement of modern tanks resulted in the development of antitank guided missiles, which in turn led to a new stage in improvement of tanks and development of new methods of their employment and countermeasures against ATGM. Therefore there are no objective grounds to claim the decline of tank troops and that the tank has become obsolete on the battlefield.

Extensively employing modes of group and individual protection and countermeasures against ATGM, tank troops can successfully operate on the battlefields and maintain their predominance. As foreign military experts believe, the tank will continue operating effectively on the battlefield for a long time to come and will constitute one of the principal factors in achieving victory in nuclear war. Therefore one of the principal tasks of tank officers and combined-arms commanders is the search for methods of tank operations in the war of today, in which battlefields will be saturated by all types of antitank weapons.

Chapter 3. MOVEMENT OF TANK TROOPS

1. Contemporary Warfare and Space

The entire history of the art of warfare constitutes a continuous process of evolution of the means and modes of waging war. Weapons and other military equipment have changed and improved, and the modes of waging war have correspondingly changed. Development of modes of conduct of combat operations was accompanied by an increase in the spatial scope of the battlefield and war as a whole.

If we trace the process of growth of the spatial dimensions of combat operations, we can establish a definite pattern, which consists in the following: the dimensions of the battlefield and war as a whole have increased proportionately to increase in the power and range of weapons and increase in the maneuver capabilities of armed forces. In other words, the greater the quantity of manpower and weapons, the better their performance characteristics (range, casualty effects, mobility), the larger the territory required for waging combat. The scale of maneuver of troops increases in connection with this, the conditions of their movement become more complex, and the character of maneuver changes.

Up to and including the 19th century, wars were restricted to that territory on which combat operations were directly conducted. The area over which a battle took place was easily observable from a single command post.

Adoption in the military of mass quantities of new weapons, which provided a sharp increase in volume of fire and troop maneuver capabilities, led to a situation where by World War I the framework of combat operations had greatly expanded, continuous fronts had appeared, and substantial territory adjacent to the battle line was now part of the area of military operations.

The spatial scale of areas of combat operations increased to an even greater extent in World War II. Battles were fought along gigantic continuous fronts, and the combat zone included substantial areas located deep within the territories of the belligerent nations.

The process of increase in the spatial scale of engagements and operations was accompanied by change in the scale of troop movements. The larger the combat zone became, the more frequently there occurred the need to improve tactical and operational maneuvers for the sake of gaining victory over the adversary. Simultaneously with this there occurred an increase in the role and significance of troop movements and depth of maneuver. Achievement of success in any engagement and operation was becoming increasingly dependent on quickness of troop maneuver.

Experience indicates that whoever skillfully utilized capability to execute broad maneuver of men and weapons for the purpose of achieving superiority in manpower and weapons on a decisive axis, invariably secured the conditions for achieving victory. In February 1944, for example, the German-fascist command was attempting to rescue the troops of the encircled Korsun'-Shevchenkovskiy force by mounting an attack with substantial forces in the vicinity of Lisyanka, but this attempt proved fruitless. Following a skillfully executed maneuver, the III and XVI Tank Corps and the XI Guards Tank Corps reached the threatened sector in a timely manner and mounted a powerful attack on the enemy.

In the past war tank troops very frequently shifted position both within the boundaries of a battlefield and outside combat zones. These movements accounted for approximately 60 percent of their total time of combat operations.

The role of movements will become even more important in a future war. The highly mobile character of combat operations, the possibility of mass casualties and the necessity of rapidly building up the efforts of forward-echelon troops, increased capabilities of the adversary to disrupt troop movements by rail, as well as increased march capabilities of tank troops -- all this can result in a large portion of combat activities of tank troops consisting in movement in march formation. It is also claimed that the depth of movement of tank troops by their own transport resources will increase.

In the past war, in spite of the fact that combat operations were conducted over vast territories, a theater of war could be arbitrarily divided into the area in which combat operations were being conducted and an area which was relatively calm and in which the occurrence of war was indicated only by indirect signs. In these conditions tank and mechanized troops, when moving large distances, could travel by rail right up to the zone immediately adjacent to the front. Air power was unable to break up rail traffic deep in the rear. Therefore tank and mechanized troops unloading areas were frequently 150-200 km or even less from the line contact. After unloading from trains, tank units and combined units as a rule had sufficient time to become fully combat ready and for thorough organization of movement and comprehensive preparation for forthcoming combat operations.

It is true that in the course of World War II there were cases where tank and mechanized troops were forced to cover great distances as well under their own power. In July 1943, for example, the IV Guards Tank Corps successfully executed a march from the vicinity of Zemlyansk to the Oboyan' area, a length of 450 km, while in August 1944 the IV Guards Mechanized Corps traveled a distance of 600 km, from Dorobyantsu to Burgas.

It is noted in the foreign military press that under conditions of combat operations with employment of nuclear weapons, weapons are capable of surmounting any obstacles within minutes and of delivering a devastating attack on any target, at any distance. Consequently the most important rail and highway junctions, bridges, dams, as well as airfields and seaports may be subjected to nuclear attack and be put out of commission for an extended period of time. This nature of physical destruction on lines of communication limits possibilities of moving troops by rail or water transport. Therefore under these conditions tank troops will most frequently travel even large distances under their own power.

It is believed that the character of movement will also change to a significant degree. In the past troops, when executing a movement, were subjected to hostile countermeasures only in the immediate vicinity of the battle line, as well as on the battlefield when they would move for the purpose of taking a more advantageous position or line in relation to the adversary. In most cases conditions of troop movement outside the contact area essentially differed in no way from peacetime conditions.

In the future, as indicated in the foreign press, conditions of movement will be incomparably more complex. Troops and lines of communication at any distance from the front may be subjected to attack by offensive nuclear weapons, aircraft, airborne assault troops and reconnaissance-raiding parties, and therefore any march becomes a complex combat mission, even outside the combat zone and at a great distance from the enemy. Enemy reconnaissance-raiding parties, armed with modern weapons, can inflict heavy casualties on advancing troops and create considerable difficulties as they move forward.

Now, it is claimed in the foreign press, it will be necessary for troops to expend significant efforts on the march to maintain their combat efficiency, to negotiate obstacles, as well as to combat hostile aircraft, various enemy raiding parties and assault forces. In addition, tank troop movements can be accomplished at any time of the year, day and night, in any weather, and on various terrain, frequently off roads.

Thus the conclusion is reached that modern conditions of combat operations require of tank troops the ability to travel long distances, at high speeds, and to arrive in the destination area on schedule, at full strength, and maintaining full readiness to engage.

2. Modes of Travel. Long-Distance Marches

Under present-day conditions tank troops may travel under their own power (that is, by march), rail and water transport, and combined mode, with simultaneous or sequential utilization of two or several modes of transport.

Selection of mode of troop transport is influenced by various factors: objective, scale, depth of movement, time allocated for its execution, status of lines of communication, availability and capability of means of transportation, condition of routes of movement, and character of enemy activities.

Movement of tank troops under their own power. As is noted in the foreign press, this type of movement is of particular significance, since it corresponds to the greatest degree to the demands and conditions of modern warfare. It is believed that travel by tank troops under their own power has a number of advantages in comparison with other modes of travel. First of all, a march ensures achieving a high rate of movement. It is apparent from the following graph (Figure 6.3.1), prepared on the basis of data in the foreign press pertaining to a U.S. Army armored division and a FRG Army tank division, that rail transport of troops provides a time savings in comparison with movement under their own power only when traveling a distance of 2,000 km. In their opinion, the advantages of tank troops traveling under their own power are not limited merely to achieving a high rate of movement. Of primary significance under present-day conditions is securement of the organizational integrity of subunits, and their constant readiness to perform combat missions at all stages of movement. Today this requirement evidently can be met with troops traveling under their own power. In addition, when executing a march under their own power, tank troops have better capability to maneuver for the purpose of crossing or bypassing zones of physical destruction and radioactive contamination, and also possess relative independence of large stationary installations on lines of communication, which can be destroyed by the enemy.

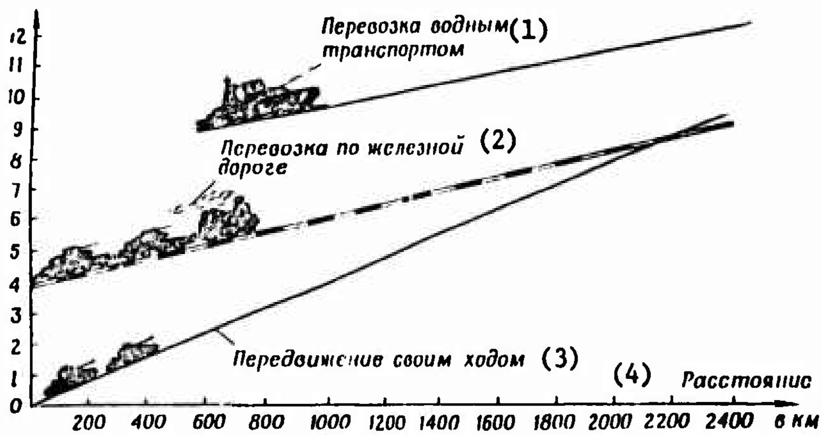


Figure 6.3.1. Graph of Time Expenditures When an Armored Division Travels by Various Modes

Key:

1. Travel by water transport
2. Travel by rail
3. Travel under own power
4. Distance

Let us see what march capabilities are possessed by tank troops. The principal indicators characterizing the march capabilities of troops are average rate of movement, vehicle range on one fueling, motor capacity, and tracks. March capabilities depend on proficiency of driver personnel, ability of commanders to lead columns, state of equipment, routes, and weather.

We know that the average rate of movement of troops depends primarily on the maneuver and operational characteristics of combat and transport vehicles. During the Great Patriotic War tank units and combined units, equipped with T-34 tanks, executed marches at an average speed of 20-25 km/h. In September 1944, for example, the V Guards Tank Corps traveled at an average of 20-25 km/h for a distance of more than 300 km. Today's tanks boast better performance, and therefore the average rate of movement of tank troops today can be greater.

The rate of movement of columns, and consequently troop march capabilities are significantly affected by the level of proficiency of driver personnel. For example, top proficiency-rated drivers can drive the same vehicles, under identical conditions, at an average speed of 25-30 percent greater than drivers of the lowest proficiency rating.

The physical capabilities of personnel are also of great importance. It is believed abroad that 12-14 hours at the controls can be a normal daily work load for drivers. Of the remaining hours in the day, drivers should spend 5-6 hours resting, 1.5-4 hours taking meals, and approximately 3-4 hours servicing their tank. Proceeding from this calculation and allowable average speeds, tank columns, in the opinion of U.S. military experts, can cover a distance of 300 km in a 24-hour period.

Tank range on one fueling, by motor capacity and tracks is an important factor which influences troop march capabilities. Range on one fueling for today's principal foreign tanks (M60A1, Leopard 2, AMX-30, Sheridan) can be approximately 500 km on one fueling, 6,500 km or more by motor capacity, and up to 8,000 km for tracks.

It follows from the above that modern tank troops possess excellent march capabilities and are capable of executing marches of considerable distances at a rapid pace under complex situation conditions, while maintaining a high degree of combat readiness.

Tank troops travel by rail. In spite of the obvious advantages of traveling under their own power, in many instances tank troops, when traveling great distances, will employ another mode of travel -- travel by rail. This mode of transportation makes it possible quickly and more economically to accomplish the mission of moving large masses of troops. Combat vehicles do not run up mileage, less personnel energy is expended, and troops can travel at high speed in all weather. But this mode of travel also has drawbacks. The most important is the fact that the organizational integrity of subunits and units is disrupted. In addition, units stretch out to considerable depth, because of which, after the first trains arrive in the new area, troops require a certain amount of time to reach a battleworthy state. As is noted in the foreign press, another serious drawback is the fact that man-made structures on rail lines are vulnerable to attack by nuclear missile weapons, airstrikes, and attacks by enemy raiding-reconnaissance parties.

Capabilities to move tank troops by rail transport depend primarily on speed of loading and off-loading, speed of trains, rail line traffic capacity, and availability of loading areas and rolling stock.

During World War II, when moving tank units by rail in the European countries, the rate of movement of trains amounted to 300-500 km per day. In the summer of 1944, for example, during movement by rail of units of the German-fascist 9th and 10th Panzer divisions from Poland to Nancy, trains traveled at a rate of more than 400 km per day.

Under present-day conditions, in connection with further development and improvement of the rail network, as well as upgrading of rolling stock, including motive power, train speeds have increased. Foreign military experts recommend that these capabilities be utilized in a period of conduct of combat operations without employment of nuclear weapons, and in a number of instances even with employment of nuclear weapons, although the traffic capacity of rail lines may sharply decrease.

Carrying tank troops by water transport. This mode is employed chiefly in transporting troops from one theater to another. Transporting tank troops in coastal sectors will obviously involve considerable difficulties which, according to data in the foreign press, consist primarily in the following.

Under present-day conditions large numbers of ships will be required to transport tank troops by water. According to figures in the foreign press, for example, more than 20 large transports are required to move one armored division. It is believed that it will be difficult to assign such a large number of transports, since with the outbreak of hostilities means of transportation at the disposal of the military will be utilized on a priority basis for delivering amphibious landing forces. As combat experience indicates, this will require a large number of ships. In the amphibious landing operation in Korea in September 1950, for example, the Americans employed a total of 250 warships and vessels to land a reinforced Marine division and an infantry division (a total of 40,000 men).

Another difficulty lies in the fact that special cargo handling equipment is required for loading and off-loading tanks and other heavy equipment, which will be in short supply with mass shipping of men and equipment and if port facilities are damaged by attack. As a consequence of this, loading and off-loading of tank troops will require considerable time. In addition, it will be necessary to assign certain naval and air forces to escort a convoy of transports to the destinations, diversion of which to perform secondary missions is undesirable.

Foreign military experts reach a conclusion from all this that water transport cannot be widely employed at the present time for transporting tank troops in coastal sectors.

The situation may change in the future, however. Foreign military leaders attach great importance to construction of large tank landing ships. Such vessels make it possible to load and off-load personnel and equipment from an unequipped shore, substantially reducing loading and off-loading time. In connection with this, capabilities to move tank troops by water transport are increased.

3. Organization of March and March Support

It is believed that timely and comprehensive preparation for movement predetermines the success of a march to a significant degree. In order for tank troops to be able to utilize in full measure all their maneuver capabilities, comprehensive

preparation for and organization of a march are essential, which will require a certain amount of time. At the same time, under present-day conditions it will obviously often be necessary to organize movement of troops on a tight timetable. Control agencies may be faced with the necessity of accomplishing several tasks simultaneously: making troops combat ready, restoring their battleworthiness, as well as other measures. This will require of commanders and staffs a high degree of organization and work efficiency. Only under this condition will there be created guarantees that all requisite measures pertaining to preparing for movement will be accomplished on a tight timetable.

A high degree of organization and efficiency in the performance of control agencies in organizing troop movements can be achieved as a result of application of the most expedient, scientifically substantiated methods of decision-making and movement planning. Only with correct methods is it possible to guarantee the performance of control agencies and to reduce their work to a specific system, to ensure efficient sequential and parallel work by several echelons.

The conditions under which preparation for travel takes place can be quite diversified, and therefore one must assume that the work methods of control agencies will also be diversified. Certain general principles, however, are characteristic of this work.

Combat experience has shown that in conditions where there is inadequate time for organizing troop movement, staffs usually employ approximately the following method.

Upon receiving a task assignment, the commander studied it together with his closest aides. Parallel with this, the mission was marked on a map. Following mission briefing, those items were determined which had to be handled without delay. First of all the matter of organization of reconnaissance and security was determined, as well as traffic control service.

Then the main decision items (depth of march, routes, march formation, start point and start point passage time by heads of columns) were determined on the basis of a concise estimate of the principal situation elements and consolidated calculations. In order to reduce decision-making time, reference figures prepared in advance by the staff were utilized, particularly such data as quantity and status of weapons and equipment, quantity of supplies available, and calculations for movement in several variants (depending on the march formation, road and other situation conditions).

Warning orders would be issued on the basis of the march plan, indicating length of march, routes, and start point passage time.

After this the commander and his aides would calculate the march in detail, determine time of troop passage of control points and arrival in the destination area (if not specified by the higher command echelon), would work out matters of march support, would complete preparation of a road movement graph, and would draw up written combat documents. If the necessity arose, the commander would refine his decision.

This method shortens the time required to organize a march, since it makes it possible to organize parallel work at several echelons and promotes precise, purposeful efforts by all control agencies.

A march decision can be correct only when it takes into account the situation and requirements of forthcoming combat operations and is based on thorough, precise calculations. One should bear in mind that movement is not an end in itself; it creates favorable preconditions for accomplishing the principal mission, defeating the adversary in combat.

It is noted in the foreign press that under conditions of massive employment of modern weapons and highly mobile ground and airborne assault troops, the situation may change rapidly and abruptly in the course of a march. Therefore traveling subunits and units, even at a considerable distance from the line of contact, may be forced without warning to engage the enemy. On the basis of this, foreign military experts advance the demand that, when making his march decision, the commander should first of all determine a plan of action in case of an encounter with the enemy and should specify what grouping of forces should be secured in the designated area. These questions are obviously of determining significance for elaboration of other decision elements and, in particular, elements such as structure of the march formation, routes, movement support, etc. As is emphasized in the foreign military press, there does not exist a standard march formation. It depends on the presumed actions taken by the adversary, the assigned mission, existence and state of roads, weather conditions, and troop march capabilities.

In determining march formation one usually proceeds from the position that it ensure combat independence and stability of march columns against enemy weapons, freedom of maneuver and continuous readiness for rapid deployment into combat formation, optimal conditions for control, logistical support and maximum utilization of vehicle performance capabilities, preservation of combat equipment and conservation of energy of personnel, etc.

Not all these demands, however, are equally important in all circumstances. Depending on concrete conditions, sometimes one demand and at other times another demand is the most important. For example, in executing a march under conditions where direct encounter with the enemy is little probable, means of transport are utilized in the most efficient manner.

If tanks are executing a march when there is a threat of encountering hostile ground troops, the interests of conduct of combat against the enemy are paramount. Therefore it is recommended that the march formation ensure rapid dispersion of troops and prompt deployment into combat formations upon encountering the enemy, ensuring swift deployment and engagement without a halt in attack position.

Timely and organized movement of tank troops depends in large measure on precise planning. The essence of march planning consists in performing various calculations and in concrete determination of the sequence of troop actions during the movement, as well as in elaboration of comprehensive support measures. Of all the calculations performed by the staff, calculation of the march is the most complex and laborious.

March calculation for tank subunits and units executing a march with organic vehicles consists in distributing allocated time among movement, rest, messing, refueling, maintenance and inspection of equipment, as well as in determining the time the column will take to pass a given point, time of passage of the start point and control points, and time of arrival in the destination area. Fuel consumption is also determined in performing march calculations.

The principal demand on a troop movement calculation is accuracy, which is achieved by carefully taking account of all the conditions of the movement. Even minor errors in calculations can lead to serious consequences (to delay in reaching destination areas or deployment lines, to creation of traffic jams on roads and in front of obstacles, and to troop casualties at these locations).

As is noted in the foreign military press, initial data for march calculation usually include composition of troops, routes; number and length of march segments; time allocated for accomplishing the march; march formation; rate of movement of march columns on individual route segments; start point and traffic control points; areas and duration of halt (day's halt, night halts).

In order to reduce the time required to perform march calculations, such data as number of vehicles in subunits, march formation variants, column length, composition of reconnaissance agencies, march security, traffic control manpower and facilities obviously will be prepared by the staff in advance and be detailed when the mission is assigned. Various slide rules, tables, graphs, nomograms and other automation devices can be used to speed up calculations.

Figure 6.3.2 contains a nomogram (set up with logarithm scales) for determination of column length based on number of vehicles and vehicle lead, as well as time distance on the basis of road distance and rate of march.

It is convenient to utilize a scale rule to perform rough operational-tactical calculations (Figure 6.3.3).

The march plan is drawn up as a result of performed calculations, indicating all principal measures pertaining to troop movement. It is one of the principal planning documents.

Organization of movement under present-day conditions is not limited to reaching the commander's decision, formulation of missions, and planning the movement. Of great importance for successful execution of a march are measures pertaining to combat, special and rear services support of the march, the purpose of which is to provide the troops with conditions for successful accomplishment of the assigned tasks, to protect them from surprise air and ground attack, to maintain their fighting efficiency and to give them the opportunity promptly to execute dispersion or maneuver in order to bypass dangerous areas, successfully to accomplish a movement under any and all situation conditions, and to provide the troops with everything they need.

The inevitability of an abrupt situation change in the course of a march, increased capability to hit troops in movement, the great length of marches and high rate of march introduce, as is indicated in the foreign press, a number of specific

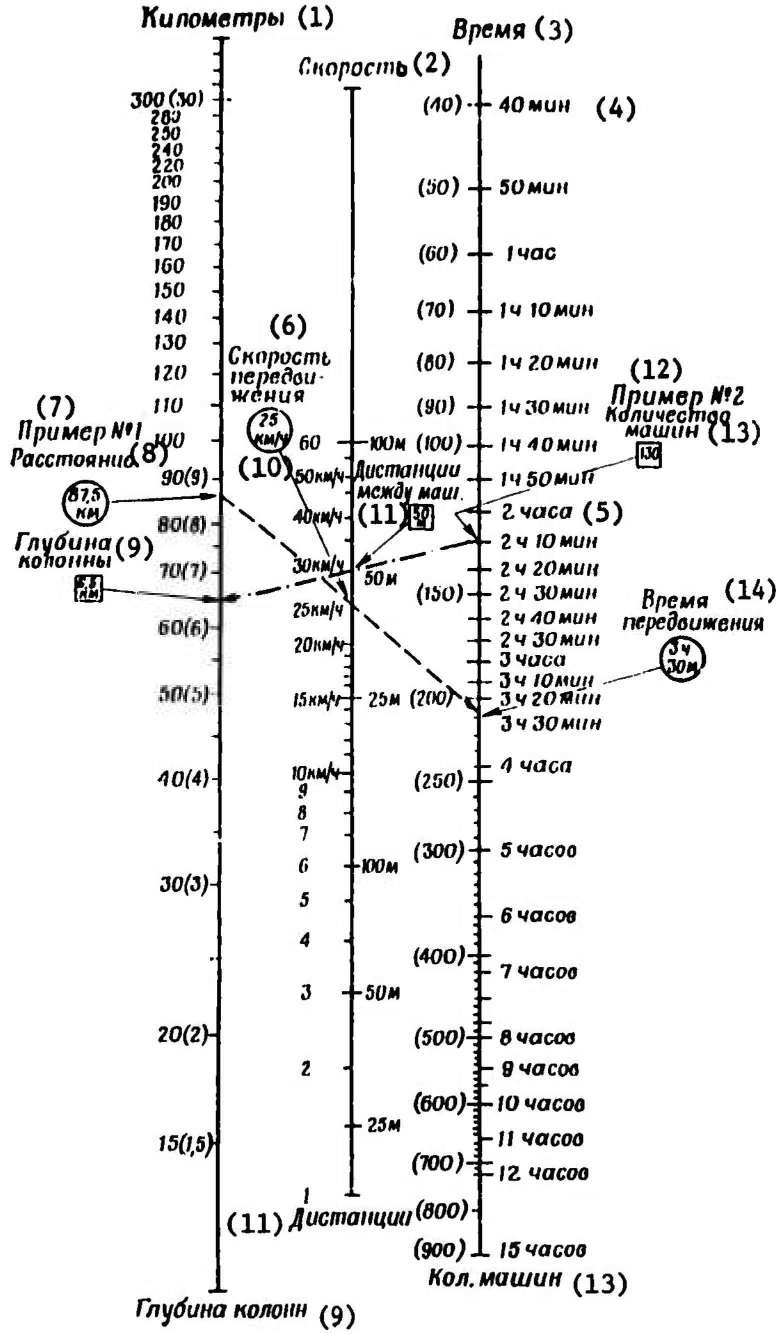


Figure 6.3.2. Nomogram for Determining Column Length and Time Distance

Key:

1. Kilometers
2. Speed
3. Time
4. Minutes
5. Hours
6. Rate of march
7. Example 1
8. Road distance
9. Column length
10. km/h
11. Lead
12. Example 2
13. Number of vehicle
14. Time distance

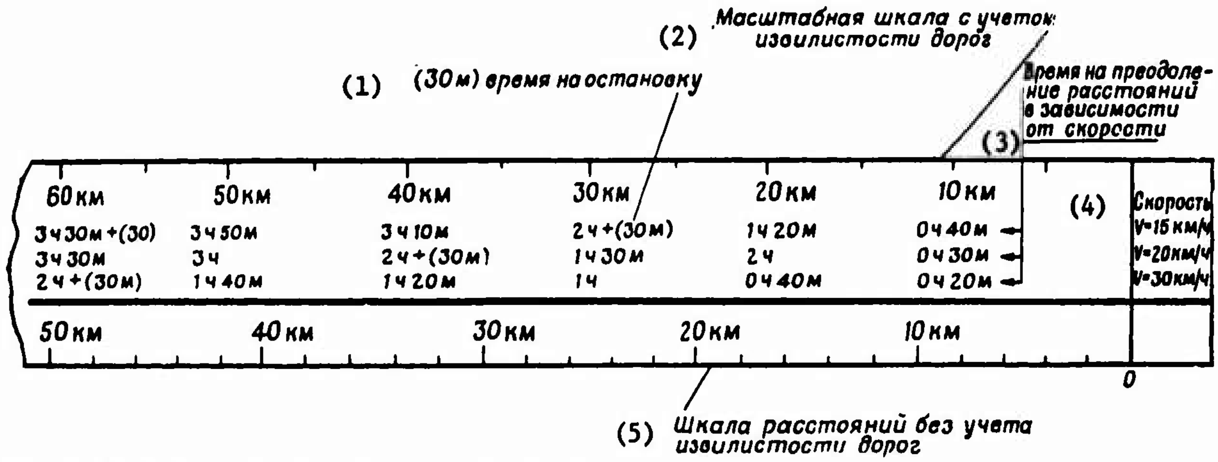


Figure 6.3.3. Rule for March Calculation

Key:

1. Halt time
2. Scale taking into account road twisting
3. Time distance in relation to speed
4. Speed
5. Scale of distances, without taking road twisting account

---

features into the form and content of support. For example, at a considerable distance from hostile ground troops main efforts in the area of troop march support are focused on providing columns with cover against air attack, on providing security to roads, bridges, river crossings and the entire march formation against surprise attacks by various partisan forces. As a column approaches the front, march combat support is subordinated to the interests of engagement of the troops and creation of the most favorable conditions for deployment.

Due to the great number of measures pertaining to support as well as their complexity, they cannot be fully examined in this volume. Therefore we shall discuss below only certain aspects of security and traffic control.

Reconnaissance. In the opinion of foreign military experts, organization of reconnaissance during long-distance movements involves certain difficulties. This is due to the lack of situation clarity to the entire distance of the march and increase in the extent of missions performed by reconnaissance. In addition to normal missions of spotting the enemy, reconnaissance is assigned missions pertaining to determination of routes, degree of terrain trafficability off roads, and collection of information on the radiation and bacteriological (biological) situation along the route and in the troop concentration area.

The capabilities of troops en route to conduct reconnaissance are limited. This can be compensated to a certain degree by obtaining requisite information from higher headquarters and directly from air reconnaissance, and as the troops approach the front -- from units operating out ahead.

It is noted that intelligence obtained from these sources cannot fully satisfy the command when making the march decision, as a consequence of which it may become

necessary to supplement or refine the information obtained from higher headquarters. Reconnaissance subunits of the moving troops will perform these missions, concentrating their attention on obtaining information on those vehicles and installations which are of the greatest interest at this time. It is quite obvious that this will affect the composition of reconnaissance agencies, their place in the march and distance from the main forces.

Therefore when the mission is received, each route is reconnoitered, with a detailed study of the terrain (the state not only of the roads as a whole, but also individual stretches, condition of bridges, river crossing sites, etc), determination of potential areas of dropping (landing) airborne assault forces along the route of movement, spotting of obstacles and detection of contaminated areas, scouting out bypass routes around these areas, and detailed information on the radiation and biological situation.

As is noted in the foreign press, during execution of a march under conditions of absence of threat of encountering the enemy, reconnaissance teams on board helicopters are sent out in advance to reconnoiter routes, halt and rest areas, and to select control facility sites, as well as engineer reconnaissance patrols and traffic control subunits.

Sending out reconnaissance teams does not exclude detailing reconnaissance subunits for conducting ground reconnaissance, detailing the condition of individual sections of road, detour routes, marking them, determining the boundaries of contaminated areas, areas of physical destruction, etc.

If a march is being executed in anticipation of engagement, main efforts are focused on reconnoitering the enemy. Strong reconnaissance patrols are established for this purpose.

Foreign military experts believe that the pace of conduct of reconnaissance is somewhat slower than the potential rate of movement of troop columns. Therefore helicopters and fixed-wing aircraft are employed in some armies to speed up the pace of conduct of reconnaissance. In the U.S. Army, for example, air reconnaissance at the division level is conducted by fixed-wing and rotary-wing aircraft of the aerial reconnaissance company of a reconnaissance battalion and army aviation battalion to a depth of 150 km. Of course these agencies conduct reconnaissance in close coordination with ground reconnaissance agencies, devoting particular attention to route reconnaissance and, if a meeting engagement occurs, they observe combat actions and adjust artillery fire.

Foreign military experts emphasize that reconnaissance missions can be successfully performed if not only reconnaissance but also march security subunits are assigned to this mission, as well as manpower and equipment from the main force columns.

Security. Modern conditions of movement of tank troops require organization of march security capable of ensuring unhindered movement of main force columns, of warning the protected troops of a surprise enemy attack, providing conditions for engagement and preventing penetration of hostile ground reconnaissance to the route of movement of the protected troops.

At the same time, foreign military experts believe that the situation and conditions of movement will demand great efforts in organizing such security. Increase in the effective range of offensive weapons and a rapid rate of closing of opposing forces require that security agencies be at a substantial distance from the main forces. In addition, an excessively large gap between forward subunits and the main forces impedes engagement of the main forces, does not help in seizing the initiative, and deprives a force of advantages in building up efforts upon encountering the enemy. Therefore at the present time it is believed in the armies of the NATO countries that troop security missions can be accomplished by coordinated efforts of reconnaissance, covering force and march security subunits, personnel and weapons assigned to security and defense of vehicles and facilities en route, as well as constant readines on the part of all subunits to perform particular combat missions pertaining to supporting the movement of the main forces.

In the absence of a stable front and threat of meeting engagements, many foreign armies follow the practice of sending out covering units. These units beat the adversary in seizing important positions, and support deployment and engagement of the main forces. They are also assigned the mission of conducting reconnaissance along the route of movement of friendly forces. In contrast to an advance guard, forward forces operate at a greater distance from the main forces, reach the destination earlier, and therefore encounter the enemy sooner.

As a rule security subunits are sent out a short distance ahead of the main forces. In the U.S. Army, for example, the advance guard of each division main force column includes up to a reinforced battalion. Depending on the situation, the advance guard should be far enough ahead to ensure gaining time and deployment of the main force column beyond the range of aimed artillery fire.

According to information in the foreign press, however, advance guards can be even further ahead, such as in those instances where more than 30 minutes is required for deploying and readying to fire those weapons moving up under the cover of the advance guard.

In executing a march deep to the rear of friendly forces, columns can be provided cover solely by immediate security. In the opinion of foreign military experts, under present-day conditions tank troops will experience great difficulties in organizing flank security, since it is capable of covering only a portion of the main force column of protected troops.

The little effectiveness of flank security is complicated in many instances by a lack of suitable roads. As a rule forced to travel on ill-suited, difficult roads or cross-country, flank guards have inevitably fallen behind their guarded columns.

Missions of covering the main forces in NATO armies are assigned to a subunit which moves as an element of the column on the threatened flank. At the same time the main force column is continuously air-patrolled. The column commander, upon receiving intelligence, immediately moves the designated subunit to the threatened sector. Stationary flank guards are set out where the threat of enemy advance and attack is most probable.

Under present-day conditions, traffic control and regulating have assumed exceptional importance. To the normal tasks assigned the traffic control service (regulating movement, monitoring and inspection to ensure that troops observe the established procedure of movement, camouflage and concealment measures), in connection with the threat of employment of nuclear weapons, are added such tasks as route security, conduct of radiological and chemical reconnaissance, engagement of enemy reconnaissance-raiding parties, assistance to control agencies in troop control, as well as securement of the organized movement of the local civilian population.

The increased volume of tasks evokes the necessity of increasing expenditure of manpower and equipment. Personnel and equipment requirements will be especially large during execution of a long-distance march. It is claimed abroad that under these conditions it will be necessary to assign to each route two traffic control details, which can perform their tasks sequentially by leapfrogging, at day's march intervals.

Some foreign military experts believe that one way to reduce expenditure of personnel and equipment on organization of traffic control and regulating is extensive adoption of the method of escorting columns by traffic control subunits. Such a method of regulating traffic is successfully employed, for example, in the armies of the NATO countries. Mobile regulating posts proceed at the head of the column in automobiles (motorcycles), halting oncoming vehicles by signals, and setting up stationary regulation posts where necessary. Another mobile post proceeds at the tail of the column, preventing the column from being overtaken and removing traffic controllers set out by the column-head mobile post.

Such a method of traffic control is also advantageous because it enables commanders to move columns confidently at maximum possible speed. This is due to the fact that commanders reconnoiter the route thoroughly and in advance, are thoroughly briefed not only on route condition, but also on alternate routes, detours, detours around built-up areas, obstacles, alternate river crossings, etc.

Escorting columns with a mobile traffic control detail, however, does not mean elimination of the system of stationary traffic control and regulating posts. There remains the need to set out stationary posts at railroad crossings, at river-crossing sites, and in large built-up areas, but their number is greatly reduced with the above traffic control variant.

4. Execution of a March

Depending on the situation of the troops, a march may be preceded by forming up march columns and moving them out past the start point, which requires a considerable time expenditure. In addition, reconnaissance entities, traffic control subunits, security and other combat support subunits are usually sent out ahead before the main forces proceed to move. All this, under conditions of an acute shortage of time, demands particular flexibility and efficiency in the performance of commanders and staffs.

The march begins at the moment when the start point is passed by the heads of the main force columns. The success of the march movement will depend to a certain

degree on how promptly troops pass this point and their degree of organization. It is therefore not surprising that in the past war troop passage of the start point would usually be monitored by staff officers. These officers, possessing information on the composition of the columns, their structure, and the precise schedule of departure of units and subunits, could when necessary take measures on the spot to impose order and ensured organized commencement of a march. Movement of march columns in the course of a march is usually controlled with intermediate passage points.

At the commencement of a march, in addition to control to ensure on-schedule troop passage of the start point and intermediate control points, commanders and staffs devote particular attention to ensuring that troops observe the specified march order and discipline, and ensure that columns move at the specified speed and in the specified direction. For this purpose, specially designated officers at control points monitor the state of the passing troops, collect situation data and report this data to headquarters.

We should note that the command experiences considerable difficulties in exercising continuous troop control, especially when particular tasks arise (crossing rivers, contamination zones, restoring battleworthiness, destroying airborne assault forces, etc). The main difficulty lies in the fact that control should be exercised in the course of movement of control agencies and troops with major restrictions in utilization of radio communication gear.

In order to overcome these difficulties, it is recommended in the foreign military press that command posts set up on helicopters be extensively utilized for troop control under these conditions.

Maintaining organization and discipline on a march ensures its successful execution. Columns and individual vehicles drive only on the right side of the road. Each vehicle proceeds in its assigned position in the column, maintaining the specified speed and gap. Vehicles which fall behind retake their places at the next halt. The necessity may arise for one column to pass another. This is permitted, however, only with the authorization of the senior commander and with observance of measures preventing accidents between vehicles and mixing up of subunits. When such a passing is required, the column being passed halts on the right shoulder or off the road to the right.

It is very important to ensure unimpeded passage of large built-up areas. In the past war tank troops as a rule slowed down considerably in towns and cities. Under present-day conditions, with a greater probability of formation of all kinds of obstacles in built-up areas, it is essential to endeavor to bypass them. If no bypass routes are available, traffic control is set up in built-up areas. Columns pass through built-up areas in the specified order, without halt, with increased gaps, and at the greatest possible speed.

Tank subunits and units may execute marches at night for purposes of concealment, at which time a complete blackout is particularly important. In this case drivers employ night vision devices. During daylight hours troops are dispersed along the routes back from the main road, observing camouflage and concealment procedures. During daylight hours personnel inspect and maintain equipment, take meals and rest.

Utilization only of the hours of darkness for executing movements, however, has the drawback that the pace of a night march is slower than that of a daylight march. Therefore, as is indicated by the foreign military press, troops may also move during the day, but in small, compact groups.

In the course of a march, when there occurs the threat of enemy employment of nuclear weapons, upon receiving an appropriate warning signal, the troops take requisite protective measures and continue moving. At the same time surveillance, radiological and chemical reconnaissance are stepped up, and appropriate instruments are switched on more frequently than usual.

When the enemy delivers nuclear strikes, those subunits which have maintained their battleworthiness shall continue moving in order to leave as quickly as possible the areas of physical destruction and heavy radioactive contamination. The commander and his staff shall estimate the situation, determine the status of the subunits which have been hit by enemy attack, and shall take measures to restore their combat efficiency. Neutralization of the consequences of nuclear strikes should not delay the movement of battleworthy troops. The roadway shall be rapidly clear of burned-out and damaged vehicles.

In the course of a march it may become necessary for tanks to negotiate a contaminated zone or to get out of such a zone as quickly as possible. Obviously the method of crossing a contaminated zone will be determined on the basis of levels of radiation in the zone, length of routes and possible speed of movement along them, as well as the demands of the operational-tactical situation. Contaminated zones shall be crossed at the maximum allowable speed in a direction ensuring the least degree of irradiation of personnel. These directions, as is noted in the foreign press, can be indicated by radiological reconnaissance by helicopter. In the contaminated zone gaps between vehicles shall be increased sufficiently so that dust from the vehicle ahead does not strike the following vehicle.

Contamination zones can also be bypassed, but usually with the permission of or on orders by the senior commander. This is due to the fact that bypassing always requires a route change. while an independent change of direction of movement without taking into account the missions of adjacent units can lead to crossing of routes and formation of traffic jams on roads.

Zones with high radiation levels, detouring around which is impossible or inadvisable, will evidently be crossed after high radiation levels drop off, by decision of the senior commander. After leaving a contamination zone, partial decontamination will be performed at the first opportunity (usually on halts and day's halts), casualties will be determined, as well as the degree of radioactive contamination of personnel.

During a march under present-day conditions, troops may be subjected to air attack at practically any distance from the line of contact. Therefore a high degree of preparedness to repel hostile aircraft and to diminish the effectiveness of airstrikes is maintained during the entire march and during halts. Troop actions on the appearance of enemy airplanes and helicopters can vary, depending on the situation. When natural screens are available along a road, a column shall halt

along a route segment sheltered from aerial observation. If movement is occurring on open terrain, subunits shall continue movement, increasing gaps between vehicles, and sometimes assuming a dispersed formation as well. All weapons which can engage hostile aircraft shall open fire.

Protection of moving troops against actions by partisan forces and enemy airborne assault forces assumes great importance under present-day conditions.

Foreign military experts believe that in order successfully to handle airborne assault forces and partisans, it is essential that all necessary measures be specified in advance, while the commander is formulating his decision and during preparation for the march.

It is pointed out that in the course of a march, with acquisition of intelligence on areas of partisan activities and enemy airborne assault forces, troops shall take measures to beef up reconnaissance, security of bridges and other bottlenecks on the immediately protected route. Columns are patrolled by helicopter gunships. It is believed that only minimal forces must be enlisted for aggressive actions against partisan forces and enemy airborne assaults, primarily reconnaissance subunits, march security, traffic control service, as well as subunits specially assigned to these missions.

The main body of troops should continue moving in order to reach the destination on schedule, maintaining a high level of combat efficiency. There may also occur departures from this principle, however. It is possible that tank subunits in the march formation will be called on to destroy airborne assault forces and raiding-reconnaissance detachments.

Thus the success of a march depends on thorough organization and comprehensive support, firm control and observance of discipline.

Chapter 4. MEETING ENGAGEMENTS -- ADMIRABLY SUITED FOR TANK TROOPS

1. Essence of the Meeting Engagement

Characteristic of modern combat operations are a large scale, rapid pace, swift and abrupt situation changes. In connection with the extensive adoption of tanks in the armies of all major countries, combat operations have become swift and mobile. In the course of these operations, conditions for the occurrence of meeting engagements and encounter battles become particularly frequent, in which the principal advantages of tank troops are manifested most fully -- great striking power and firepower, high mobility and survivability.

Considerable attention has always been devoted to elaboration of theory of the meeting engagement in Soviet art of warfare. Analysis of Red Army combat operations in the civil war and subsequently in the Great Patriotic War were the basis for this.

Classic examples of the conduct of successful meeting engagements with large, highly mobile enemy forces were provided by the Red Army cavalry in the civil war at Orel, Kromy, Voronezh, and Kastornaya. Its swift and surprise attacks on the enemy from the flanks and rear swiftly broke up superior enemy forces and made it possible subsequently to crush them piecemeal in short order. In the majority of engagements the Red Army cavalry in the civil war achieved victory by virtue of swiftness of actions and concealed maneuver, while not possessing superiority of forces over the enemy.

Taking into account the experience of combat employment of cavalry, as well as correctly evaluating the capabilities of a new combat arm -- tanks -- Soviet military theorists noted in the first years after the civil war that massed employment of large tank combined units, in coordination with other forces and weapons, substantially expands the offensive capabilities of troops and dictates the occurrence of meeting engagements. The essence of the meeting engagement as a mobile type of offensive action in which both sides seek to accomplish their missions by attack was quite clearly defined. It was believed that meeting engagements will most frequently begin directly from the march (Provisional Field Service Regulations of the Workers and Peasants Red Army, Moscow, Voyenizdat, 1936, page 140).

During the Great Patriotic War theory of the meeting engagement experienced further development. In particular, practical experience indicated that meeting engagements

can occur not only from the march but also in the course of an attack or in the defense (during the conduct of counterattacks against an advancing adversary). For example, the Field Manual of Red Army Armored and Mechanized Troops (Part II, page 297), published in 1944, stated that "the meeting engagement of armored and mechanized troops is usually conducted deep in the enemy's dispositions during exploitation of success or during mounting of counterthrusts against an advancing adversary." The definition of the essence of the meeting engagement as given in the prewar years was confirmed.

During the Great Patriotic War many tank brigades, corps and armies successfully conducted meeting engagements and encounter battles during penetration of the defense and exploitation in depth of offensive success, during pursuit, in crushing counterattacking and counterthrusting enemy forces, as well as in the course of defensive actions in mounting counterattacks and counterthrusts.

It is noted in the foreign military press that under conditions of nuclear missile warfare, due to the specific character of development of weaponry and mass equipping of ground forces with tanks and other highly mobile, high firepower armored vehicles, there will evidently be even greater preconditions for the occurrence of meeting engagements and encounter battles. Famous military theorist Liddell Hart claims, for example, that in future wars top-echelon commanders, in contrast to their predecessors, will seek to achieve decisive results primarily by movement rather than battles. He believes that in a nuclear missile war maneuver and movement will essentially constitute the principal content of troop actions. In an article entitled "Tanks and Their Future," Liddell Hart emphasizes that there may be not only small tank units possessing maximum flexibility of action on the battlefield and therefore capable of quickly shifting from one action to another, but entire divisions as well, capable of swiftly maneuvering from one area to another and hitting the enemy with counterthrusts. Foreign experts have also noted in their statements that under present-day conditions meeting engagements may occur both during offensive and defensive operations, as well as during redeployments directly from march formation.

During the conduct of offensive operations, a swift breakthrough by tanks deep into the enemy's defenses will naturally evoke corresponding countermeasures in the form of counterattacks and counterthrusts. Because of the decisiveness of objectives pursued by counterattacking or counterthrusting enemy forces, combat against such forces will most frequently assume the form of meeting engagements and encounter battles.

During the Great Patriotic War, in January 1945, in the course of the Vistula-Oder Operation, the enemy mounted a counterthrust with the forces of the XXIV Panzer Corps (three divisions in strength) against the troops of the advancing 4th Tank Army. As a result a large meeting engagement took place near Kielce, in which combined units of the 4th Tank Army, utilizing maneuver, surprise and mounting attacks on the enemy from the flanks and rear, totally crushed a powerful enemy force. The enemy lost 180 tanks and assault guns in this battle.

It is believed abroad that in the course of defensive operations by friendly forces in combat against an adversary who is exploiting offensive success, tank troops will be most frequently employed for counterattacks and counterthrusts, which will also lead to meeting engagements and encounter battles. The 5th Guards Tank Army

was utilized in this manner in the past war during the Battle of Kursk. By mounting a powerful encounter attack with the tank corps of the 5th Guards Tank Army against the main panzer force of the German-fascist army, the German offensive was halted. As a result of a savage encounter battle and heroic actions by the tank crews of the 5th Guards Tank Army, hundreds of German tanks were destroyed, and destroyed along with them were the hopes of the fascist command for achieving decisive success in the summer campaign of 1943.

Thus meeting engagements have been and remain the foundation of the conduct of combat actions by tank troops. Considerable striking power and firepower as well as high mobility enable tank troops to attack the enemy not only with a superiority in forces but also with equal and even inferior forces.

2. Conditions for the Occurrence of Meeting Engagements

The experience of past wars indicates that meeting engagements have occurred and can occur in the attack, defense, and directly from march formation.

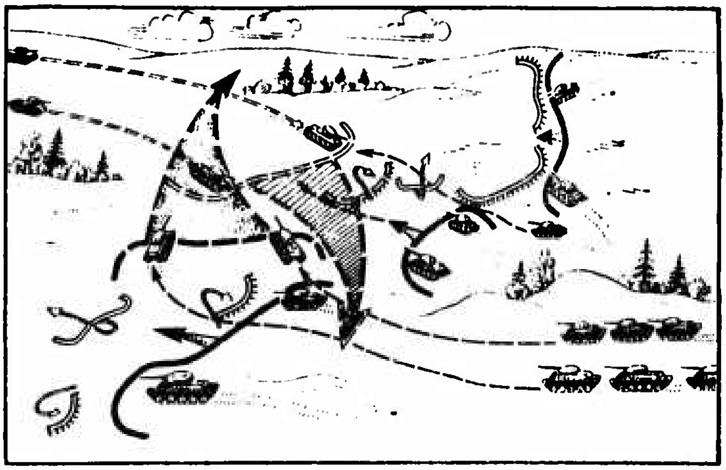


Figure 6.4.1. Occurrence of a Meeting Engagement with Counterattacking Enemy Reserves in the Course of an Attack

According to the views of foreign military experts, a meeting engagement for tanks in the attack may occur during penetration of the enemy's defense and exploitation in depth, when the adversary seeks to break up the advance with counterattacks by support echelons and immediate reserves (Figure 6.4.1). In this case characteristic of the advancing force in the forward echelon of tanks is the fact that their forces are usually already deployed into combat formation, while all or part of the weapons are in position. In addition, control, communications and coordination of these forces are already organized, and a system of comprehensive support is functioning.

All this makes it possible, as is noted in the foreign press, to hit the adversary with already deployed forces and weapons more swiftly than if this were to be accomplished following preliminary deployment from columns, and also makes it

possible in the shortest possible time to organize or refine coordination, control and comprehensive support.

Upon entering a meeting engagement in the course of an advance, forward-echelon troops are helped by the presence of adjacent units in successfully accomplishing their missions. Foreign military experts believe that adjacent units can secure the flank and prevent a surprise enemy attack. The presence of adjacent units makes it possible to concentrate maximum forces on a decisive axis, although, on the other hand, it still somewhat restricts maneuver capability to attack the flanks of the advancing enemy. In addition, with a combat formation set up for fighting a directly defending adversary, under conditions of limited time it is very difficult to establish the combat formation which is necessary and more advantageous in a meeting engagement. The stronger the resistance of the opposing enemy force, the greater is this complexity. Therefore subunits, units or combined units advancing in the attack echelon cannot always conduct a meeting engagement with a counterattacking adversary with utilization of the requisite quantity of available forces and weapons.

It is also noted that the advancing troops may have sustained considerable casualties by the time of engagement. This also complicates combat against a strong counterattacking adversary, since under these conditions it is not always possible to utilize such factors as beating the enemy to the attack, the element of surprise, and attack into the flank and rear.

Under the above conditions, prior to entering a meeting engagement with an enemy force advancing for a counterattack, there may occur the necessity of first seizing and holding an advantageous position and carrying out a number of measures to thwart the organized advance and deployment of the approaching enemy. And all this will take place under fire delivered by the opposing enemy force. Consequently, entry into a meeting engagement in the course of an advance by attack-echelon forces is one of the most complex conditions of occurrence of a meeting engagement.

During the Great Patriotic War entry into meeting engagements between advancing troops and counterattacking enemy reserves occurred both on the scale of units and combined units and on the scale of tank armies. A typical example was the encounter battle between the 4th Tank Army and the enemy's XXIV Panzer Corps on 13-14 January 1945 in an area south of Kielce. Army combined units entered into an encounter battle directly from march formation, essentially at the commencement of the operation (on the second day).

The foreign press notes that entry into a meeting engagement is less complex for units and combined units which prior to this were in the support echelon (reserve). In this case the attack-echelon troops localize aggressive actions by defending enemy forces and create favorable conditions for deployment and establishment of a combat formation required by the situation by the forces of the support echelon which are advancing to engage. Under these conditions support-echelon troops can establish a combat formation which is fully in conformity with the general plan of action of the meeting engagement and which is not burdened by the mission of mopping up the defending enemy force. Troops committed to battle from the support echelon are able more freely to select the main axis of advance, and sometimes can execute a maneuver to hit the flank of the advancing adversary.

A certain amount of time is needed, however, to prepare support-echelon forces to engage and fight, time which will be limited by the actions of the advancing adversary. Therefore, as a consequence of limited time, some matters pertaining to support, and particularly coordination, may be settled in insufficient detail under these conditions, since it is not possible to specify all situation features prior to engagement. For this reason all matters not decided in advance are usually subsequently worked up and detailed as additional information is obtained.

It is noted in the foreign press that most frequently meeting engagements will occur during exploitation in depth, when armored units and combined units will fight meeting engagements with advancing enemy reserves -- from depth or from other sectors of the front. Under these conditions units and combined units usually operate by axes with substantial gaps between adjacent units, and sometimes separated from them.

It is believed that, possessing reconnaissance operating in depth and a high degree of mobility, tank units and combined units, when fighting actions in depth, are able swiftly to drive forward to the avenues of advance of enemy reserves, to beat them in seizing advantageous positions and to attack enemy reserves from the flanks and rear. Considerable freedom of maneuver and the capability to achieve the element of surprise enable tank units and combined units operating at depth to deliver the most powerful attacks on advancing enemy reserves, attacks corresponding to a maximum degree to their combat capabilities.

In the Lublin-Brest Operation in July 1944, brigades of the III Tank Corps, pursuing the retreating enemy, reached the avenues of withdrawal of his Brest force. The enemy mounted a counterattack in order to clear the routes of withdrawal for his troops. In the vicinity of Jakubow a meeting engagement was fought between part of the forces of the 5th Goering Panzer Division and the corps 103d Tank Brigade (see Figure 6.4.4).

When the brigade encountered the enemy, it was deployed on a broad front and had exposed flanks. The success of the engagement was determined by swiftness of attack on the enemy through gaps in his combat formations and a drive into his rear, as well as precise coordination with the 50th Tank Brigade, which attacked units of the enemy's 5th Panzer Division on the flank in the vicinity of Jakubow.

The experience of tank troops combat operations during the Great Patriotic War indicated that upon advancing deep, tank units and combined units as a rule would attack only the enemy's flank and rear, executing concealed turning movements and bold raids for this purpose. Such, for example, were actions by the tank corps and brigades of the 2d Guards Tank Army in January-February 1944 in meeting engagements with German-fascist troops at Uman', Zhitomir, and Korsun'-Shevchenkovskiy. In the above-mentioned encounter battle of the 4th Tank Army in January 1945, the X Tank Corps and VI Mechanized Corps hit the enemy's 17th Panzer Division on two flanks and crushed it.

Based on the experience of the past war, during actions at depth tank troops as a rule would enter meeting engagements (encounter battles) independently, in the absence of adjacent units, which demanded the conduct of all-round reconnaissance and assignment of a portion of forces to repel possible attacks by a flanking adversary prior to encountering his main forces.

Typical of conditions for the occurrence of meeting engagements is limited time for organization, sometimes a substantial separation from other forces, and exposed flanks and rear. The circumstances of occurrence of meeting engagements during actions in depth may also be unclear. In this connection one can expect surprise attacks by the enemy and his unexpected appearance from different directions.

Of course under these conditions commanders may not possess sufficient information for making a decision to engage. The vagueness of the situation, however, does not exempt them from prompt decision-making. Under these conditions, during the war years troops aggressively acquired new intelligence and conducted continuous reconnaissance on a broad front and to considerable depth.

In the conduct of defensive operations during the war years, meeting engagements took place with an adversary exploiting offensive success -- with his attack-echelon units which had been able to advance swiftly deep, or with support-echelon (reserve) units committed to battle to exploit offensive success.

Specific features of situation conditions during the conduct of counterattacks or counterthrusts in the course of defense included a substantial enemy superiority in personnel and weapons, the enemy's seizure of the initiative, and the possibility of changing the course of combat operations at any moment by mounting additional attacks and shifting efforts.

Of importance in this connection was skillful utilization of the advantages of the defending troops -- concealed preparation for a counterattack and its surprise execution, fullest utilization of advantageous terrain conditions and advance preparation of deployment lines.

A meeting engagement of counterattacking units in the support echelon (reserve) of defending troops would usually be executed in coordination with the forward-echelon troops. Consequently, in these conditions they usually would have adjacent units, the enemy would be known, routes of advance, deployment lines and lines of shift to counterattack would have been reconnoitered and sometimes prepared, matters pertaining to mutual support would have been in principle determined in advance, and control, communications and support would be organized. At the same time one should bear in mind that in the course of combat forward-echelon subunits may sustain considerable casualties, and therefore their stability will not be identical on all axes. In this connection prior specified coordination with them may frequently be disrupted, while directions of counterattacks will require refinement.

A characteristic feature of the conditions of occurrence of a meeting engagement in the course of a defensive battle, that is, with the conduct of counterattack, is a continuous and abrupt situation change. This can require considerable flexibility and efficiency in the work performed by commanders in organizing for combat. In a number of instances it may also be necessary to alter the general plan of action.

Modes of action in a meeting engagement in the course of counterattacks can naturally be varied, depending on the opposing force -- forward-echelon units or fresh reserves. Different variants are examined in the foreign press. In one instance, for example, a counterattack should be swift, prepared as quickly as possible and executed at that moment when the enemy is halted and has not yet had time to dig in.

In order to gain time, a counterattack may be mounted immediately following an artillery strike on the enemy and along the shortest axis. If a meeting engagement is fought with subunits and units exploiting offensive success, the countering force will obviously need close mutual support with the forward-echelon units, and joint delivery both of fire for effect and execution of attack on the adversary.

In another case, when the adversary commits his support echelon or reserves to intensify a successful offensive drive, counterattacking forces may also fight a meeting engagement independently. They can execute a concealed maneuver in order to attack the enemy in the flank.

It is believed that under conditions of conduct of high-mobility actions, various redeployments will be carried out on a large scale. Under conditions of absence of continuous fronts, with abrupt situation changes in the course of such redeployments, armored troops may enter meeting engagements directly from march formation.

Initiation of a meeting engagement directly from march formation occurred extensively in the Great Patriotic War. Large redeployments of troops, especially tank troops, were typical in this period. In June 1941, for example, the 23d Tank Division, 22d Mechanized Division, and the VIII Mechanized Corps entered a meeting engagement from march formation. Engagement from march formation is also possible when advancing toward a boundary, to points of engagement to exploit offensive success, and to repulse attacks by an advancing adversary.

In all cases of engagement from march formation, experience has shown that success was achieved by thorough organization and comprehensive march support.

Thus meeting engagements can commence from an attack, during the conduct of defensive actions, and from march formation. They can occur both at the beginning of an operation (battle), in the course of the exploitation phase, and at the concluding stages.

The experience of the past war demonstrated and the character of present-day conditions confirms that meeting engagements can be fought both night and day, on any terrain and in any weather. The high mobility and maneuverability of tank troops enable them to fight meeting engagements in any situation condition, even the most complex.

3. Characteristic Features of the Tank Troops Meeting Engagement

Meeting engagements are characterized by a number of typical traits dictated by the specific features of the situation during their initiation and conduct.

In a meeting engagement both sides seek to achieve their objectives by means of swift offensive actions. Characteristic of this type of engagement is closing of the opposing forces and consequently rapid engagement even with a relatively large initial distance between them. In this connection the fact of limited time for organization for combat is both a condition for and one of the principal typical traits of a meeting engagement.

The fact of limited time in a meeting engagement requires that all calculations for delivering fire for effect on the enemy, for deployment of troops and other actions be performed as quickly as possible. The duration of time for organization for actions in a meeting engagement in each concrete instance usually has certain limits, which must be observed in order not to end up in a less advantageous position than the opposing side. The point here is that when there occurs a combat situation in which a meeting engagement is possible, the opposing forces are at a certain specified distance from each other and, traveling at a speed possible for the given concrete conditions, may encounter one another after a quite specific time interval.

Consequently, in order to engage in an organized manner and to be well prepared and thoroughly prepared for combat, troops should within the time available execute all requisite actions and measures ensuring success in combat. In addition, in order to place the adversary in less favorable conditions, it is essential to execute all actions and measures swiftly, in order to beat the adversary in delivery of effective fire, in deployment and shift to the assault.

In practical terms, in the modern meeting engagement the time count breaks down literally into hours and minutes. As regards delivery of fire between tanks and tanks or tanks and antitank weapons directly on the battlefield, time is counted in seconds here, just as in other types of engagement.

Because of limited time, and as a consequence of the maneuver character of actions in the initial stages of a meeting engagement, as mentioned above, the situation can frequently be vague. This feature of the meeting engagement is dictated by the fact that in the endeavor by the opposing sides to keep their troops from being hit by the enemy, they take all steps to conceal their movement, to delude the enemy and thus to ensure the element of surprise in mounting their attack both in time and place.

The experience of the past war demonstrated that although the fact that opposing sides have at their disposal highly effective intelligence gathering means helps positively resolve the question of spotting the enemy in advance, it does not totally eliminate the problem. In contrast to the conditions of an attack on a defending adversary, when his forces, although camouflaged and concealed, can be determined fairly completely, since they remain for an extended period of time practically in a single location, in a meeting engagement the enemy's personnel and weapons are in movement, and therefore they may again become "lost" following detection. Because of this specific feature, the missions of reconnaissance in a meeting engagement have always been more complex than in other types of engagement.

As a consequence of the fact that troops have exposed flanks, characteristic of a meeting engagement are actions on a broad front with the execution of maneuver to reach the enemy's flanks and rear. Execution of such a maneuver is usually connected with the appearance of a sometimes considerable gap between the forces executing it and the troops operating frontally. As a result the overall fighting frontage in a meeting engagement increases substantially in comparison with an attack on a defending adversary. For example, during the Great Patriotic War brigades attacked on a frontage of from 1 to 2 km, and divisions -- usually in a zone of from 2 to 4 km, while in meeting engagements the fighting frontage of tank

brigades amounted to 4-6 km, with 10-12 km and more for tank divisions (early in the war) and tank corps (in the middle and at the end of the war).

In connection with an increase in frontage and enhancement of the role of independent actions by subunits and units in a meeting engagement, a specific feature in the combat formation arises -- the necessity of having the bulk of personnel and weapons available for mounting the main attack. Subunits and units fighting on the flank and driving to the enemy's rear should have a high degree of independence.

As a consequence of swift closing of the opposing forces and abrupt situation changes, maneuvering to the adversary's flanks and uneven advance by troops in a meeting engagement, the so-called battle line or line of contact can have a sharply irregular configuration, and there can occur frequent and deep penetration by the opposing forces. Since in a meeting engagement both sides seek to accomplish their missions by attack, different missions may arise for individual elements of the combat formation. According to the views of foreign military experts, in these conditions it is advisable for the bulk of one's forces to advance on one axis, with a limited number of troops on another axis. Characteristic of the meeting engagement during the Great Patriotic War was a specific division of forward-echelon forces into two parts -- a blocking force, with the mission of halting the enemy's main forces, and a main force, with the mission of mounting the main attack on the enemy and crushing him.

Another characteristic feature of a meeting engagement is the fact that as a rule the mutual position of the combat formation elements changes very rapidly due to swift and abrupt situation changes in such an engagement. This dictates especially high demands on efficiency in the performance of commanders and staffs both in collecting situation data and prompt detailing of missions to subordinate forces and weapons.

Meeting engagements of tank troops are usually very brief. In the opinion of foreign experts, a surprise, resolute assault following brief but heavy delivery of fire on the enemy can quickly lead to victory not only over an adversary with equal but even superior forces. The term short duration of a meeting engagement is relative, however. The fact is that in many instances one of the opposing sides, following a clash between the main forces, and sometimes only the forward subunits (units), having determined the adversary's superiority, may immediately break off offensive actions.* Under these conditions it is considered that a meeting engagement is of short duration only in the sense that it essentially encompasses only the brief initial period of clash between the opposing forces. Therefore although combat will continue, it will essentially possess different forms, contrasting to an engagement where both sides seek to achieve their objectives by attack.

During the war meeting engagements were conducted by both sides with employment of aggressive offensive actions until one of the forces was victorious. In this case

* See "Sukhoputnyye voyska kapitalisticheskikh gosudarstv" [Ground Forces of Capitalist Nations], Moscow, Voyenizdat, 1974, page 197.

they naturally were of considerable duration. Tank battalions and brigades, for example, would achieve success in a meeting engagement in 1-3 hours, while tank corps sometimes required from 10 to 30 hours of intensive fighting to defeat the adversary (the XXIX Tank Corps in battle with the German-fascist 3d Panzer Division in January 1944; the X Guards Tank Corps and the enemy's 17th Panzer Division in January 1944; etc).

The short duration of a meeting engagement as one of its typical features is grounded in the very foundation of this type of combat action by tank troops. Not being connected with holding any line or position, and offering considerable freedom for execution of concealed maneuver, selection of time and advantageous place of action and utilizing the element of surprise, tank subunits and units can execute maneuver in order to crush the adversary with an initial powerful attack.

One distinctive feature of meeting engagements, dictated by the decisiveness of objectives, mounting of surprise attacks, and short duration, is their exceptionally intensive character. Any action of one of the sides aimed at gaining a certain advantage requires immediate execution of appropriate countermeasures by the opposing side. Otherwise more favorable conditions are created for the first side to continue combat which, with equal forces, enables that side to hold the initiative and rapidly achieve decisive success.

In connection with the above, in the endeavor to secure an advantage by maneuver and attacking first, each of the opposing forces will continuously undertake the most persistent measures to create a favorable position in respect to the adversary. Since this process is mutual, the initiative in a meeting engagement can frequently and rapidly shift from one side to the other, which makes a meeting engagement exceptionally intense. As a consequence of the high degree of intensity in a meeting engagement, there will occur deep penetration into the enemy's dispositions by a portion of one's forces, with simultaneous repelling of attacks by superior enemy forces by another portion of one's forces on a different axis.

The attack in a meeting engagement is only the focus of combat actions, common in objective and content. As a consequence of frequent and abrupt situation changes and a rapid shift of initiative from one side to the other, some subunits (units) may attack while others may counterattack, mount ambushes, redeploy, and then once again engage with the most diversified missions. Such a dynamic development of combat actions is the most important distinctive feature of the meeting engagement of tank subunits and units.

Depending on the scale of a meeting engagement, its characteristic features are not always manifested identically. In a meeting engagement of small subunits, for example, it is more difficult to pin down the enemy with a portion of one's forces on one axis and at the same time to attack from the flank or rear with superior forces. Small tactical subunits operate on a relatively narrow frontage and usually in view of one another, and therefore in a meeting engagement of such subunits all available forces enter battle almost immediately after shifting to the assault phase; they operate in close contact, and the fighting is of short duration.

Meeting engagements of large tank forces, as took place, for example, in January 1945 at Kielce (4th Tank Army), in November 1943 near Fastov (3d Guards Tank Army), and in June 1944 on the Bobr River (5th Guards Tank Army), commenced and developed in the initial phase according to the classic scheme of engagement. Initially the advance guards engaged, followed by the main forces: one part of the forces pinned down a certain enemy force, while the remainder attacked the enemy force in the flank or rear. The main forces attacked the enemy on one and sometimes on two axes, that is, with envelopment of the enemy on both flanks.

In contrast to a meeting engagement of small subunits, when large tank forces clash actions develop with a great diversity of forms. It very often happens that combat actions shortly assume the form of a great many individual engagements of subunits and units dispersed laterally and in depth. In many instances these engagements assume a focal character.

Obviously these actions cannot be viewed as a simple sum of isolated engagements, since their overall content is substantially broader, for it constitutes an aggregate of engagements subordinated to a common objective and following a unified general plan for all forces.

Just as in the last war, meeting engagements of large forces may also be typical in present-day conditions. It is believed that in all probability the clashes will be of the nature of encounter battles.*

According to the figures of foreign experts, hundreds of tanks took part on both sides during the events in October 1973 in the Near East.

It is believed that the character of encounter battles in the war of today may be analogous under certain conditions to the encounter battles of World War II.**

Encounter battles of tank armies during the Great Patriotic War were fought on a frontage ranging from 20 to 40 km. Tank corps and armies took part in these battles, and they lasted up to 72 hours. Actions by tank combined units of the 5th Guards Tank Army at Prokhorovka in July 1943 and on the Bobr River in June 1944 during the rout of the enemy's 5th Panzer Division can serve to a certain degree as an example of such encounter battles.

Today's meeting engagement, which is offensive in content, at the same time encompasses an aggregate of various actions united by a single objective -- to crush the enemy with swift attacks. This makes it one of the most complex versions of an offensive operation, distinguished by exceptional intensity and determination.

4. Conditions of Achieving Success in a Meeting Engagement of Tank Troops

A meeting engagement is usually fought by equal forces in personnel and defensive weapons. As we know, however, it is almost impossible to achieve victory in a frontal engagement with equal forces. Such an engagement usually leads to mutual

* See Soviet Military Encyclopedia, Moscow, Voyenizdat, 1976, Volume 2, page 406.
** See ibid., page 407.

destruction of personnel and equipment on an approximately equal basis. It is therefore believed that essential for success in a meeting engagement are a number of specific conditions, correct utilization of which can guarantee victory not only over an adversary who is weaker or equal in numerical strength but also over a superior adversary.

In the last war major conditions for achieving victory in a meeting engagement included prompt detection of the enemy and continuous surveillance of him, reaching a decision for actions by friendly forces in the shortest possible time and prompt assignment of combat missions, and beating the adversary in seizing favorable positions and delivering airstrikes and artillery fire, as well as in deployment and shift to the assault.

Of great significance for success in a meeting engagement were the element of surprise and skillful utilization of terrain and weather, which makes it possible to execute actions which take the adversary by surprise, a powerful initial attack, execution of maneuver to attack the enemy's flank or rear, rapid splitting up of the enemy force and its piecemeal annihilation.

Victory over the enemy in a meeting engagement was also secured by seizing and holding the initiative, by bold troop actions, and by maintaining precise and continuous coordination of all forces and weapons participating in the engagement. An important role in achieving victory over the adversary in a meeting engagement was played by firm and continuous control and precise coordination of reliable protection of exposed flanks and rear.

Each of these conditions is manifested differently, depending on the concrete situation. In a meeting engagement, for example, one cannot overemphasize the importance of reconnaissance activities, since the results of reconnaissance activities essentially determine the manifestation of such factors of achievement of victory over the adversary as utilization of the element of surprise and beating the adversary in mounting attacks, swift seizure of advantageous positions, and prompt execution of maneuver into the enemy's flank or rear.

As is noted in the field manuals of a number of the world's armies, an increase in troop readiness and their increased combat and maneuver capabilities make especially important promptness and quickness of decision-making for a meeting engagement and seizure of the initiative. For successful accomplishment of these tasks, reconnaissance in a meeting engagement is conducted continuously, to considerable depth and along a broad frontage. In the last war combat and reconnaissance subunits and agencies conducted reconnaissance in subunits, units and combined units. In addition, air reconnaissance was also conducted on an operational scale, performing missions simultaneously in the interests of tank troop units and combined units. Air reconnaissance will also be conducted extensively under present-day conditions.* In a number of armies ground and air reconnaissance is conducted to a depth of up to 100 and 300 km respectively.**

* See Soviet Military Encyclopedia, Vol 2, pp 228-283.

** See "Sukhoputnyye voyska kapitalisticheskikh gosudarstv," page 197.

On the basis of the experience of the war, speed of decision-making for a meeting engagement as a factor in achieving success dictated the possibility of promptly executing a maneuver to seize an advantageous position, advance into the enemy's flank or rear, and to beat the adversary in delivering fire and going into the assault phase. As a result this helped gain an advantage over the adversary even under conditions where the overall situation was not developing to the advantage of friendly forces. During the action south of Bogodukhov, for example, units of the VI Tank Corps were pursuing a retreating enemy during the night of 11 August 1943. At 0400 the corps commander learned that enemy columns were moving out of Kovyaga; the corps was able to engage this enemy force at 0600, that is, only two hours later. Successful corps actions were achieved in these conditions because the corps had established in advance an advantageous force grouping for initiating combat from march formation and therefore was able to beat the enemy in deploying.

Beating the adversary in detection, delivery of fire, deployment and attack was decidedly a most important condition for achieving success in a meeting engagement. That side which beat the adversary in deploying and mounting an attack would achieve victory even over a numerically superior adversary. The 181st Tank Brigade, for example, during the battle of Kursk in July 1943, encountered an enemy column of approximately 40 tanks near Mikhaylovka. The enemy was routed by a swift and surprise attack by only two battalions -- one (the lead batttalion) frontally and the other from the flank -- although these battalions totaled fewer tanks.

It is noted in the foreign press that essential in order to beat the adversary in delivering fire, deployment and initiation of the attack are swiftness and accuracy of calculation of planned measures in time and space, taking account of the capabilities both of friendly and enemy troops. It is important to take into account in these calculations that the adversary will camouflage and conceal his actions and alter them abruptly in order to deceive the adversary.* Therefore when performing calculations it is considered essential to foresee the most realistic variants of possible actions by the adversary and to determine the requisite time and sequence of delivering artillery strikes, deploying and attacking with one's forces, beating the adversary in these moves.

At the beginning of the last war, in spite of the fact that the treacherously attacking enemy had the initiative for the most part, tank and mechanized corps endeavored to attack the enemy with the element of surprise and to beat him to the punch. For example, in a meeting engagement fought by the VIII Mechanized Corps near Lutsk on 26 June 1941, the 12th Tank Division succeeded in attacking first, hitting the flank of the enemy's 16th Panzer Division and advancing 15 km by that evening. The enemy sustained appreciable losses. In that same battle units of the 34th Tank Division attacked the 11th Infantry Division, routed a regiment of motorized infantry, destroying 50 tanks and armored cars, and advanced 30-40 km by the evening of 27 June.

As was noted above, beating the enemy in delivering artillery strikes, deployment and initiation of attack by the main forces is a most important condition for success in a meeting engagement. The experience of the Great Patriotic War

* See "Sukhoputnyye voyska kapitalisticheskikh gosudarstv," pp 198-199.

showed the important role of beating the adversary to the punch. Let us examine what it involved and how it was achieved.

Beating the adversary in delivering an artillery strike consisted in the following: by the time troops were ready to initiate an attack, the enemy was in effective range of artillery fire but was himself not ready to delivery artillery fire.

Beating the enemy in deploying tank units and combined units in a meeting engagement was usually accomplished by achieving a high rate of march, by conducting special measures to delay the enemy's advance, and concealment of actions. It was taken into account that in order to beat the adversary to the punch it was essential not only to cover the distance to the probable point of encounter faster than the enemy but also to hit the adversary's flank, that is, to cover an additional distance. In this connection, the rate of advance of troops for the purpose of beating the adversary in taking an advantageous position should substantially exceed the adversary's rate of movement. In cases where achievement of high speeds proved impossible for various reasons, measures were taken to delay the enemy with artillery strikes, airstrikes, and actions by advance guards. In the opinion of foreign experts, remote mining of terrain is sometimes expedient for this purpose.

At the same time, beating the adversary in deploying and a combat formation for establishing an advantageous grouping of forces in a meeting engagement also had their own specific features. On the one hand, they should be rapid enough so that the adversary is unable to take effective countermeasures, and they should end with a swift attack of the enemy immediately following air and artillery strikes. On the other hand, premature deployment of main forces could not be permitted, since in this case the adversary would be able to discover the plan of action and take appropriate measures to avoid a surprise attack.

Hitting the enemy with a strong initial attack when large forces came into contact was achieved by concentrating a maximum quantity of personnel and weapons on a decisive axis and employment of tanks in mass on this axis. This would be based on correct calculation of relative strengths and the character of actions of both sides in the prevailing situation conditions. Maximum quantity of men and weapons utilized for the attack was defined not as the maximum quantity which could be assigned to any given axis but that which would ensure a decisive superiority over the adversary on the main axis of advance and would make it possible successfully to repulse the enemy's attacks on the blocking axis.

When determining the optimal composition of forces and weapons on the main and blocking axes, one took into consideration the high probability of unexpected attacks by the enemy, which required placement of an adequate quantity of men and weapons in a combined-arms reserve.

Attaching particular importance to the requirement that the initial attack be powerful, the point was that in a meeting engagement this question should be determined in each individual instance taking account of the concrete situation features, and first and foremost proceeding from the possibility of beating the enemy to the attack and achieving the element of surprise. It was believed that superiority in forces on the main, decisive axis creates only the preconditions for achieving success, for there occurs simultaneously with this a weakening of

friendly forces on other axes, which the adversary can exploit. Therefore in a meeting engagement it was important not only to establish superiority in men and weapons on the decisive axis but also quickly to exploit that superiority.

In order to achieve maximum power of an initial tank attack, in addition to massing tanks on the decisive axis it was also necessary to hit the enemy effectively on the far approaches to the point of probable encounter with airstrikes, and subsequently with artillery. The force and power of delivery of fire on the adversary would be boosted to a maximum level just prior to initiation of the tank assault phase. In this instance the adversary would sustain considerable losses even prior to initiation of the attack and would be significantly weakened. Under such conditions the force of the initial attack on the enemy would increase substantially.

The dependence of the success and power of the initial attack in a meeting engagement on the element of surprise in its delivery was manifested in this case in achievement of victory even against a stronger adversary.

The element of surprise in a meeting engagement and encounter battle in the last war was achieved by concealed forward movement, swift execution of maneuver and beating the adversary in deploying for battle, by careful camouflage and concealment of combat formation elements, by selection of modes of action which the adversary was not expecting, by artillery strikes in secondary areas or on secondary axes for the purpose of diverting the adversary's attention from the imminent attack by the main forces on the decisive axis, And by a differing time of attacks in different areas, especially feinting attacks.

During the Great Patriotic War the element of surprise in mounting attacks by tank troops was usually achieved primarily due to their high degree of mobility and their capability of operating on practically any terrain.

The actions of the XXIV Tank Corps were indicative from the standpoint of utilizing the element of surprise. During the battle of Stalingrad, in the severe winter of 1942, within a few days time the corps had advanced more than 200 km deep into the enemy's dispositions and captured Tatsinskaya Station directly from march formation on the morning of 24 December. The appearance of tanks so far behind enemy lines and under adverse weather conditions took the fascists so much by surprise that even aircraft were unable to scramble from the airfield located near Tatsinskaya Station. As a result of this lightning strike, the tankers of this corps destroyed approximately 350 aircraft, 50 artillery pieces and 15 tanks.

Frequently tank subunits and units in the last war took advantage of adverse weather and road conditions to mount sudden attacks on the enemy, which took the latter by surprise and led to success. For example, in meeting engagements of tank and mechanized corps of the 3d Guards Tank Army at Proskurov in March 1944, the troops executed a maneuver under conditions of muddy terrain and a heavy snowfall; during hours of darkness combined units of the 3d Guards Tank Army conducted meeting engagements near Fastov; in the summer of 1944 troops of the 5th Guards Tank Army conducted night meeting engagements on the Bobr River, and in the vicinity of Vormdit in winter, in deep snow. In order to take up an advantageous position in respect to the adversary, corps forward detachments and their main

forces would take advantage of terrain enabling them to advance undetected to points at which they would shift to the attack, as well as to axes on which the adversary could not expect Soviet tanks to appear.

The element of surprise in a meeting engagement is manifested in differing ways, depending on the numerical strength of the forces involved. For small subunits, for example, the result of an attack with the element of suprise may prove decisive in the very first minutes of battle, since the element of surprise in actions of this scale usually develops quickly. At the level of combined units and large strategic formations, the element of surprise would be in effect for an extended period of time. Surprise actions by the XXIV Tank Corps, for example, enabled it successfully to batter the enemy for a period of five days. In this connection, counting on utilizing the element of suprise, the potential duration of the effective surprise would be taken into consideration, since there could come into effect after this such determining factors as relative strengths and the firepower and striking power of subunits and units of both sides.

The high mobility of tank troops enables them to execute swift maneuver which takes the enemy by surprise, essentially on any terrain and at any time, day or night. Precisely such swift mobile actions brought success to Soviet tank brigades and corps during the Great Patriotic War in meeting engagements with German-fascist units. In a meeting engagement fought in January 1945, for example, the X Tank Corps first defeated the enemy's 17th Panzer Division and then, in coordination with units of the VI Mechanized Corps, also defeated the enemy's 16th Panzer Division, which was advancing from another direction.

During the conduct of mobile actions, tank troops employ in order to achieve success in a meeting engagement such forms of maneuver as close envelopments and wide envelopments of the enemy on one or two flanks (Figure 6.4.2). Such a form of maneuver as the frontal (splitting) attack (Figure 6.4.3) was also frequently employed in tank corps and army battles in the last war. Frontal attacks were mounted by the 1st Tank Army at Bogodukhov and Akhtyrka, by the 3d Guards Tank Army at Fastov, etc. Selection of a given form of maneuver in a meeting engagement depends on the quantitative composition of troops and their mobility, available time and terrain conditions, the adversary's position and actions.

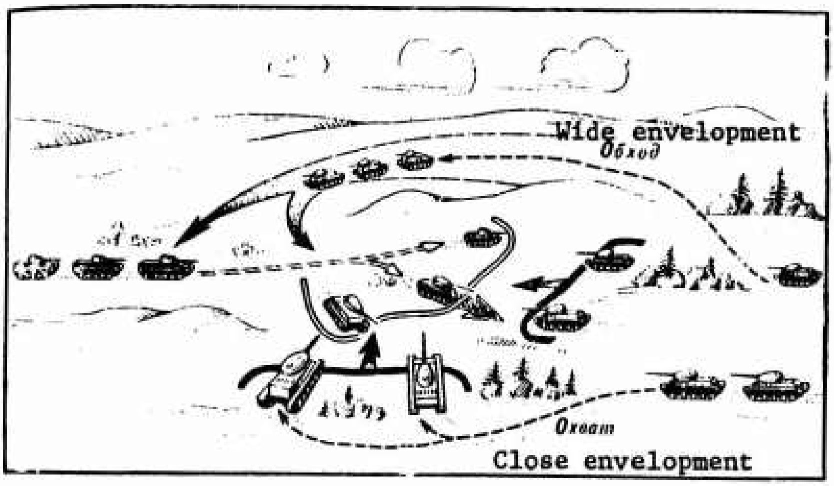


Figure 6.4.2. Wide and Close Envelopment

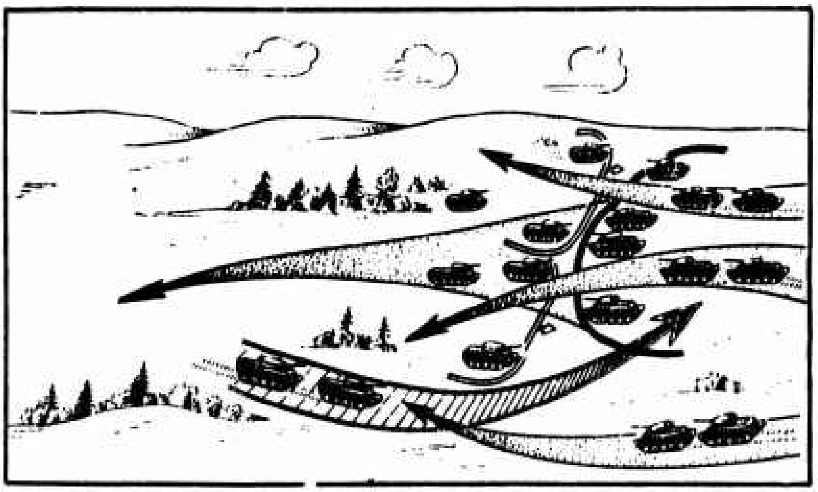


Figure 6.4.3. Frontal (Splitting) Attack

In the last war many tank brigades and corps achieved decisive success precisely because of a bold maneuver into the enemy's flanks and rear. In the meeting engagement of the 3d Tank Corps which took place on 28 July 1944 during pursuit of the retreating enemy in the vicinity of Jakubow, the 103d Tank Brigade pinned down the enemy frontally with one tank battalion, while two battalions (a tank and motorized rifle battalion) executed a wide envelopment on the enemy's flank. Simultaneously the corps attacked units of the enemy's 5th Panzer Division on the left flank with the forces of the 50th Tank Brigade. Thus the 103d Tank Brigade, in order to achieve success, executed a wide envelopment of the enemy on one of his flanks, while the corps executed a close envelopment of the enemy on both flanks (Figure 6.4.4) with the objective of destroying his personnel and weapons.

Tank subunits in a meeting engagement more frequently employ a close or wide envelopment only on one flank. This is due to the fact that subunits usually have insufficient forces to execute a close or wide envelopment maneuver on the enemy on two flanks. In addition, during the initial stages of a subunit-scale meeting engagement, both sides retain the capability aggressively to hit enveloping forces with available weapons without shifting them significantly, and therefore it is difficult to execute such a maneuver undetected, and yet without concealment of this maneuver, success may be placed in doubt. In cases where execution of maneuver by part of the forces of a subunit appears possible, however, it is usually employed without delay and produces the most appreciable results.

Employment of a concealed wide envelopment maneuver into the flank or a drive into the enemy's rear by even a small part of one's forces can compel the adversary to execute a sometimes substantial redeployment of forces and thus weaken certain axes. In February 1944, for example, in the fighting at Leningrad, a tank battalion of one of our combined units, operating in the forward detachment near the Berezhki Sovkhoz and Gorki, encountered an advancing enemy column of 20 tanks and 15 trucks carrying infantry. Frontally blocking the enemy advance party, the battalion main forces attacked it on the flank (Figure 6.4.5). The tank attack

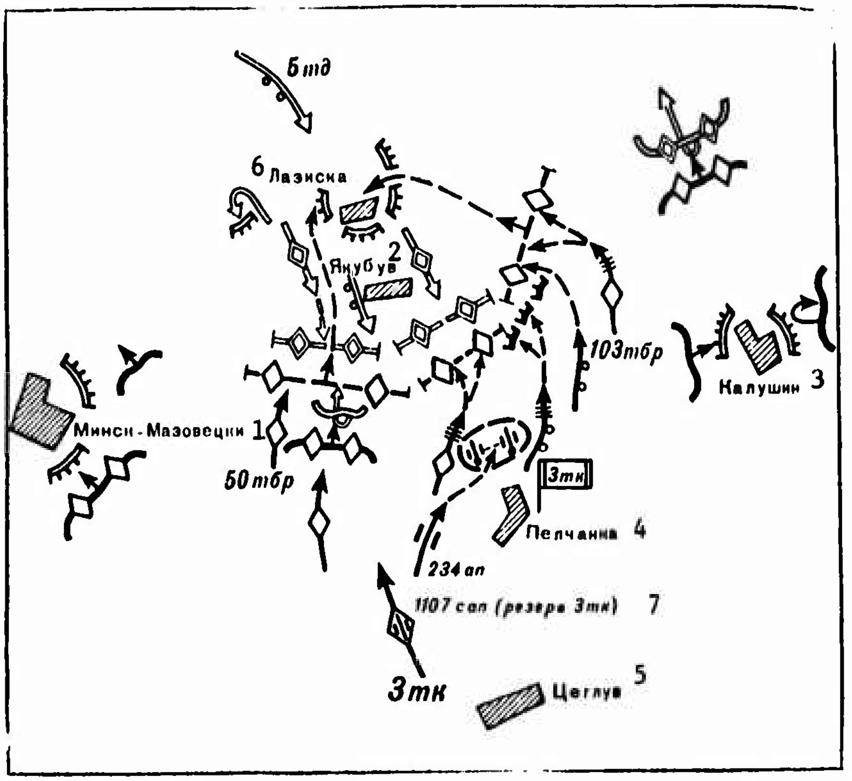


Figure 6.4.4. Meeting Engagement of the III Tank Corps on 28 July 1944 at Jakubow

Key:

1.	Minsk-Mazowiecki	7.	Reserve
2.	Jakubow	md.	Panzer division
3.	Kaluszyn	mbp.	Tank brigade
4.	Pielczanka	an.	Artillery regiment
5.	Ceglow	can.	Self-propelled artillery regiment
6.	Laziska	mk.	Tank corps

took the enemy by surprise to such an extent that the enemy force was totally crushed in short order. The battalion destroyed 13 tanks and killed 100 fascist soldiers.

When executing a maneuver in a meeting engagement, one should bear in mind that its execution is not an end in itself but a means of achieving success, making it possible to inflict the greatest damage on the adversary in the shortest period of time and with minimal friendly casualties. Therefore it is advisable only in those cases where troops will occupy a more favorable position as a result of its execution and a decisive superiority in men and weapons will be established on the axis of advance or the element of surprise will be achieved.

If, as was the case in the war years, these advantages were not secured in a wide envelopment maneuver, it was more advantageous to mount a strong attack, swiftly and with the element of surprise, frontally at the enemy's weak point, splitting the force in two and then destroying it piecemeal. Such actions were especially successful if they were executed following massive delivery of fire on the enemy with employment of all artillery and available tactical air.

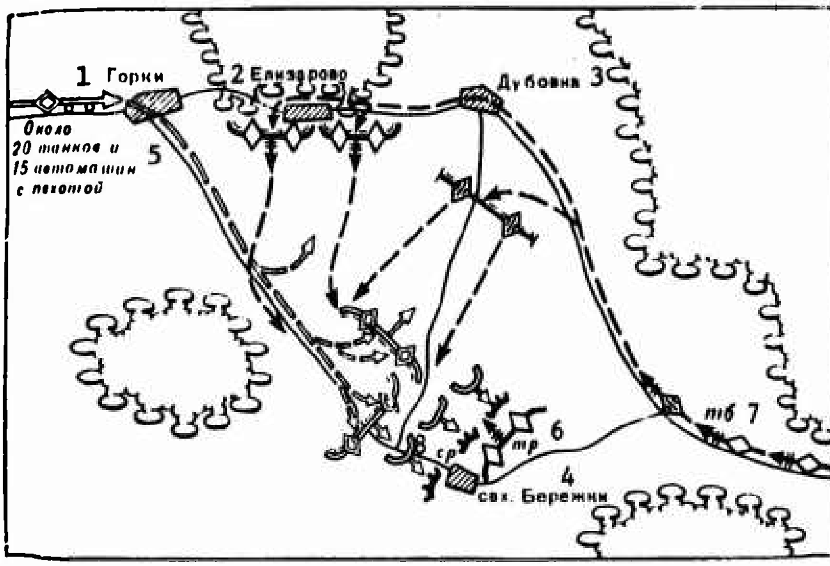


Figure 6.4.5. Maneuver in a Tank Brigade Meeting Engagement in February 1944 Near the Berezhki Sovkhoz

Key:

1. Gorki
2. Yelizarovo
3. Dubovka
4. Berezhki Sovkhoz
5. Approximately 20 tanks and 15 trucks carrying infantry
6. Tank company
7. Tank battalion
8. Rifle company

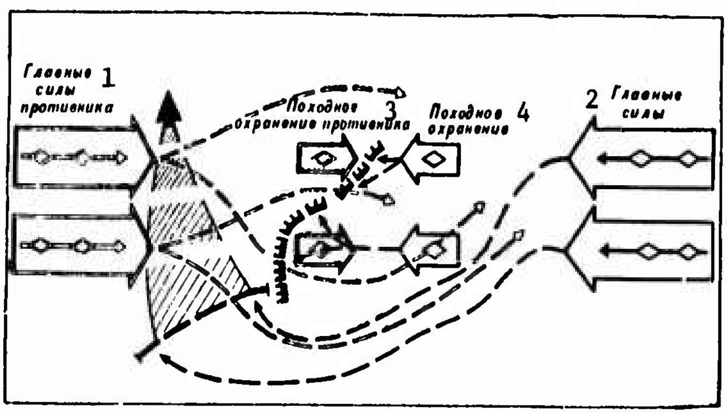


Figure 6.4.6. Interrelationship Between Form of Maneuver and Main Axis of Advance in a Meeting Engagement

Key:

1. Enemy main forces
2. Main forces
3. Enemy march security
4. March security

Experience indicated that the employment of maneuver in a meeting engagement depended in large measure on coordination among the forces attacking frontally and enveloping the enemy on the flanks. The main thing was not to execute premature or poorly concealed actions, as a result of which the enemy could discover the purpose of the maneuver and have time to take measures to counter the main force by executing his own maneuver.

One important condition for achieving success in a meeting engagement and encounter battle in the past war was correct determination of the main axis of advance against the adversary. The sequence of actions by forces and weapons employed in the past war in a meeting engagement can be schematically represented as depicted in Figure 6.4.6. For example, if in the course of a wide or close envelopment maneuver on the enemy's flanks it was possible to bring sufficient forces to one of the flanks for a powerful initial attack ensuring the enemy's defeat, as a rule units would mount the main attack on this axis. At the same time, as a rule the main attack would be directed at the weakest point of the enemy force, where tanks could operate in mass and at high speeds, and consequently most fully and effectively exploit the results of preliminary airstrikes and artillery fire.

Mounting, in the course of a meeting engagement of tank subunits, an attack with one's main forces at the enemy's weak point, into the gaps and intervals in his combat formation leads as a rule to rapid splitting of the enemy force. Rapid splitting of the enemy and his subsequent piecemeal destruction constitute the principal condition for achieving decisive success in a meeting engagement.

If the enemy force is separated even prior to engagement, it is advisable to prevent him from linking up his forces, to isolate them from one another and to smash them sequentially. For tank subunits possessing a high degree of mobility, destroying the enemy piecemeal has been and remains one of the principal methods of achieving victory.

One of the factors which ensure successful accomplishment of the mission of routing the enemy in a meeting engagement is seizing and holding the initiative. In contrast to an attack on a defending adversary, when the initiative is in the hands of the attacking force from the very outset of battle, in a meeting engagement both sides simultaneously endeavor to secure for themselves the advantage of maneuver with the element of surprise, execution of an attack which beats the adversary to the punch, and seizure of an advantageous position in respect to the enemy. Under these conditions that side which has most fully and swiftly exploited favorable circumstances will also possess much greater chances of success.

Thus, as indicated by the experience of the war, constant and comprehensive figuring by commanders of tank subunits of the continuously changing situation conditions and facts affecting achievement of success in a meeting engagement, continuous conduct of reconnaissance, maintaining continuous readiness to engage and advance establishment of a force capable of entering battle from march formation without significant change of formation, as well as prompt and full utilization of the capabilities of available personnel and weapons create a solid foundation for defeating the adversary in short order.

Under conditions of high-mobility actions, rapid and abrupt situation changes, success attends that side which devotes more attention to securing its flanks and rear, to reliable protection of its dispositions against air attack, and maintenance of firm and continuous control of forces in the course of combat.

5. Fundamentals of Organization of a Meeting Engagement in Tank Troops

Thorough organization of troop actions and their comprehensive support in a meeting engagement constitutes the foundation for successful accomplishment of all missions

arising in a clash with the enemy. Organization of a meeting engagement is affected by limited available time, situation vagueness, and the specific posture of the opposing sides -- as a rule, both advancing toward each other.

In the past war battalions, brigades, and sometimes corps frequently had from one to three hours to organize for action in a meeting engagement. Under these conditions, as a consequence of highly mobile actions by the opposing sides, decisions pertaining to the meeting engagement would be made extremely rapidly, and missions would be assigned literally in minutes. Fast determination of these questions is particularly important in order to beat the adversary in delivering artillery fire, deployment and initiation of the assault.

With limited time available, all questions pertaining to organization for a meeting engagement can be successfully settled only with advance and comprehensively planned preparation of troops for the forthcoming action. For example, when organizing for a march or during pursuit under conditions where the enemy may be encountered, as measures executed in advance the commander of a tank subunit specifies organization of reconnaissance and security, arrangement of his men and weapons considering possible engagement directly from march formation and the requirement of rapid deployment into combat formation, organization of control and communications in conformity with demands imposed on them in combat, and provision of supply to the troops, figuring on combat with a powerful adversary.

One important preparatory measure for entering a meeting engagement is, under these conditions, advance determination of the sequence of actions in case of an encounter, and establishment of an expedient force.

When organizing for an attack on a defending adversary, the commander of a tank subunit may include among measures to prepare for a meeting engagement with counterattacking enemy reserves specification of reconnaissance missions to ensure prompt spotting of approaching reserves, expedient structuring of the combat formation and distribution of personnel and weapons figured not only for defeating the defending enemy force but also fighting a meeting engagement with the enemy's reserves, and determination of matters of mutual support. Under these conditions the procedure and sequence of delivering fire on counterattacking reserves by supporting artillery and other sources of fire may be planned in advance. Advance accomplishment of these measures will make it possible to engage with the least loss of time and, most important, to beat the adversary in carrying out requisite actions.

During the Great Patriotic War, due to a lack of adequate intelligence on the enemy when organizing for actions in anticipation of a meeting engagement, a force grouping would be established so that any combat formation required by the situation could be adopted in short order with minimal displacement of force elements. Such a force grouping is made sufficiently flexible and versatile, convenient for rapid formation changes. In order to maintain a high degree of readiness to enter battle from march formation, during closing with the enemy, as additional intelligence is obtained on him, appropriate adjustments would be promptly made in the formation of friendly troops.

The commander alone makes the combat decision. At battalion level and higher, the commander is assisted by his staff. Distribution of functions at these echelons

and working method depend on the degree of coordination between commander and staff. The main requirement is to reach a decision on all matters as quickly as possible and ensuring that the greatest possible amount of time is directly made available to subordinates. In this connection, the parallel method is adopted as the basis for work on organization for a meeting engagement. With this method,* the required information and missions are communicated to subordinates as soon as they are determined, prior to completion of all work pertaining to organization for combat at the higher echelon.* This method enables one to organize for combat actions in a comparatively short period of time, due to which troops will have more time for immediate preparation to execute the assigned mission.

In connection with the fluid nature of actions by the opposing sides and the limited time available, the meeting engagement decision should be made quickly, while marching. It is based on an endeavor to beat the adversary to the punch in delivering effective fire, in deploying and initiating the assault. Therefore when the mission is received, the subunit commander shall as quickly as possible figure the time and place of encounter with the adversary, specify the general plan of action and determine the most advantageous forms of maneuver.

The decision shall be made on the basis of a thorough situation estimate and consideration of the enemy's tactics and specific capabilities of friendly forces.** During the Great Patriotic War, when a decision was being made for a meeting engagement or encounter battle, the following would be determined: an advantageous main axis of advance, sequence and procedure of delivering fire on the adversary, the force grouping required for the engagement, time of the attack, modes of actions, missions of the troops, and procedure of mutual support and control. A correct estimate of the enemy was an important factor in determining the composition and time of deployment of one's main forces. The task consisted in more accurately determining the adversary's plan, the possible time of his establishment of a force grouping for combat, its composition and formation at the commencement of battle. Due to a lack of sufficient intelligence on the enemy, a major role in an estimate was the ability of commanders to predict the possible course of the adversary's actions.

Missions of fire delivery on the enemy were determined with the aim not only of inflicting maximum possible damage but also of delaying his advance. This will make it possible on the one hand to improve the correlation of forces and on the other to gain time to deploy and attack the enemy from the most advantageous position.

In the past war, beating the adversary in establishing an expedient force grouping and its deployment for battle was precisely calculated in relation to the adversary's potential actions and readiness time. The enemy's rate of advance would be determined with this objective, and on this basis, taking account of the distance separating the opposing forces and the rate of advance of friendly troops, the specific time of encounter would be determined.

---

* See D. A. Ivanov et al, "Osnovy upravleniya voyskami" [Fundamentals of Troop Control], Moscow, Voyenizdat, 1971, page 232.
** See ibid., pp 195-196.

In order to ensure that the calculated encounter time and measures to beat the adversary to the punch proceeding from this calculation remain valid, there would subsequently be maintained continuous surveillance of the enemy, with all changes in his actions noted. With this objective, immediately after completion of time and encounter calculations, corresponding orders would be issued to detail reconnaissance missions.

In determining force composition and its time of deployment, a commander would take into consideration that under some situation conditions beating the enemy to the attack and the element of surprise could be decisive, while in other conditions the strength and force of the initial attack would be determining. The concrete situation would indicate what was more important. Everything depended on what factor was decisive in a given situation and what conditions were favorable for one side or the other.

The experience of the Great Patriotic War indicated that in a meeting engagement the combat formation of tank brigades and corps was usually set up in a single echelon with designation of a reserve. Establishment of a reserve but not a support echelon was due to the fact that because of situation vagueness, rapid and abrupt situation changes, it was impossible to assign a concrete mission to a support echelon.

As a rule a large part of available men and weapons would be designated to the attack echelon in brigades and corps, in order to deliver a powerful initial attack: two battalions out of three in the brigade, and two to three brigades out of three to four in the corps. Such a distribution of forces between attack echelon and combined-arms reserve, however, is not mandatory. If it was determined that enemy attacks from the flanks were possible in the situation, and when the opposing enemy force was not highly battleworthy but had strong reserves in a deep position, the forward echelon could contain fewer forces than indicated above, with more forces in the combined-arms reserve.

When mounting counterattacks and counterthrusts, that is, during the occurrence of a meeting engagement in the course of defensive operations, the order of battle would also be in two echelons. In the fighting at Prokhorovka on 12 July 1943, for example, the forward echelon of the XVIII Tank Corps contained the 181st and 170th Tank brigades, while the support echelon contained the 110th Tank Brigade and 32d Motorized Rifle Brigade. This was due to the fact that the corps counterthrust was conducted in a precisely defined area and missions were assigned concretely both to the forward and support echelon.

Forward detachments would be designated from units and combined units in case of a possible encounter with the adversary in the course of executing marches and during pursuit. During the past war these would be reinforced battalions in brigades and brigades in corps. Forward detachments seek to seize advantageous positions on the routes of advance of the enemy's main forces and to block them, thus ensuring favorable conditions for the brigade (corps) main forces to deploy quickly and unhindered and to initiate a decisive attack. In addition, the order of battle of brigades (corps) included an artillery group, an antitank reserve, a mobile obstacle detachment, and antiaircraft weapons.

Under present-day conditions, in connection with a constantly growing quantity of the most diversified weaponry, an increasingly important role is being played by coordinated employment of these weapons in a unified combat formation, where they, supplementing one another, are able to display their specific combat performance characteristics with the greatest effectiveness. Therefore, as is noted in the foreign press, a combat formation of tanks should also contain motorized infantry, antitank weapons, artillery, and air defense weapons.

The engagement plan is refined as the opposing forces advance to contact. Also refined is the plan for delivery of fire for effect on the enemy and, consequently, also the previously specified general plan of action and forms of maneuver. Frequently, as combat experience indicates, the plan of action is even refined upon engagement of the covering forces.

In determining the content of combat missions, the commander proceeds from the position of priority being assigned to crushing the enemy's main forces. Therefore in the past war brigades and corps in a meeting engagement were assigned an immediate mission of crushing the opposing adversary to the depth of his main forces, that is, the forward echelon. In defining the mission, troops were told the line which should be reached and taken and the time to reach it. For subsequent actions only the direction was specified, due to the highly mobile character of these actions. Evidently the content of combat missions will be similar under present-day conditions.

Meeting engagement missions in tank subunits and units are communicated by radio, by specified signals, and by brief operational instructions. In order to save time, gain bearings quickly and to give subordinates more time to prepare for combat, in the past war they were initially given only that information which was essential for immediate initiation of specific actions. Subsequently the mission would be detailed and supplemented by other essential information.

In order to achieve a high degree of efficiency of troop actions, missions were initially assigned to those forces which were to commence given activities earlier than others -- to reconnaissance agencies, covering forces, advance guards, and artillery. In order to speed up communication of missions, they would usually be transmitted with utilization of various communication channels, and in addition would be repeated on a redundant basis.

Simultaneously with assignment of missions, instructions on mutual support are also communicated to commanders of subordinate subunits. Due to limited time availability, it is difficult to organize on the terrain mutual support in a meeting engagement. In the past war the first items to be determined were troop advance, execution of maneuver and deployment, and then, as concrete information on the enemy was received, matters pertaining to delivery of fire would be determined.

Upon approaching deployment lines, when the direction of actions of the enemy's main forces and his force grouping became known, matters of mutual support when initiating the assault phase and exploitation at depth could also be concretely determined.

Mutual support of forces in a meeting engagement would be organized first and foremost on the axis of the advance of the main forces, after which mutual support

instructions would be communicated on that axis where the enemy was being blocked, and efforts would be coordinated as regards missions (positions the troops were to capture in the course of defeating the adversary), as well as objectives and time.

Matters of mutual support in a meeting engagement require constant refining, due to rapid and abrupt situation changes, as new intelligence is obtained on the enemy, especially on maneuver of his forces to the flanks and rear. In organizing mutual support, it is important thoroughly to brief subordinate commanders on their assigned missions and those of adjacent units, as well as the missions and sequence of actions of attached and supporting forces and weapons. In order to ensure maximum coordination in troop actions, commanders of all echelons must possess firm knowledge of the time and sequence of delivery of fire on the enemy by the forces and weapons of the higher commander, adjacent units, as well as their own actions during this time and immediately following artillery bombardment.

Securement of firm and continuous control occupies an important place in organizing for a meeting engagement. When moving forward, during advance to contact, the commander and his staff usually accompany the main forces (with their command post). When a subunit engages, its commander is positioned in the combat formation, proceeding on his tank at a distance from the assaulting tanks which provides good observation of the entire subunit.

In units and subunits, during deployment and engagement the commander is at his command post on the axis of advance of the main forces and displaces in order to observe the actions of tanks on this axis.

In the past war precise briefing, an expedient procedure of communicating missions, and continuously operating communications would be organized in advance in order to ensure reliable control in subunits and units (at all echelons, with adjacent units, supporting forces and weapons). Commanders and staffs were required to respond promptly to situation changes by refining plans and missions.

In view of the fact that during preparation for combat matters of support have already been settled, in anticipating a possible clash with the enemy they are usually only detailed in conformity with the actual conditions of the developing situation.

6. Actions of Tank Troops in a Meeting Engagement

As was indicated by the experience of the Great Patriotic War, success in meeting engagements and encounter battles was achieved with a high degree of aggressiveness of actions by tank units and combined units. As we know, aggressive troop actions in a meeting engagement usually would begin after reconnaissance spotted an advancing enemy force and its approach to a distance at which it could be hit by air and artillery. Even prior to these strikes, however, covering forces (if designated) and main forces would begin to advance to axes and lines ensuring occupation of an advantageous position in respect to the enemy and enabling one to attack with the element of surprise and beating the enemy to the punch.

Security subunits (advance guards) or the covering force, upon encountering an inferior or equal enemy force, would attack it from march formation and seize

positions advantageous for subsequent actions by the friendly main forces. During a meeting engagement with such an enemy force, security subunits would employ wide envelopments, close envelopments, and would frontally attack the enemy with a small part of their forces and hit the flanks with the remaining forces. They would endeavor to attack at a moment when the enemy was in column formation. In order to beat the enemy in delivering fire, artillery would deploy from march formation, without considering convenience of position, and would open fire as rapidly as possible.

It was believed that frontal attacks and an unexpected attack from the flank, surprise tank fire from ambush, as well as delivery of stationary fire for effect on one axis with a simultaneous assault on another could enable subunits operating as security or in the covering force to destroy in short order not only an equal but superior enemy force as well. In a number of instances the aggressive actions of these subunits (units) forced the adversary to deploy his main forces as well. Thanks to such actions by covering forces, the main forces were able to execute an advantageous maneuver unhindered and to deliver a powerful attack on the enemy in a situation which was disadvantageous to the latter.

When covering force subunits encountered a superior enemy force, they would detail a small part of their forces for frontal actions, while the remaining forces would execute a concealed maneuver to deliver a surprise attack on the enemy from the flank or rear. In order to ensure the element of surprise in this attack, they would move along terrain irregularities, ravines, small woodlands, and areas where the enemy was not expecting troops to appear.

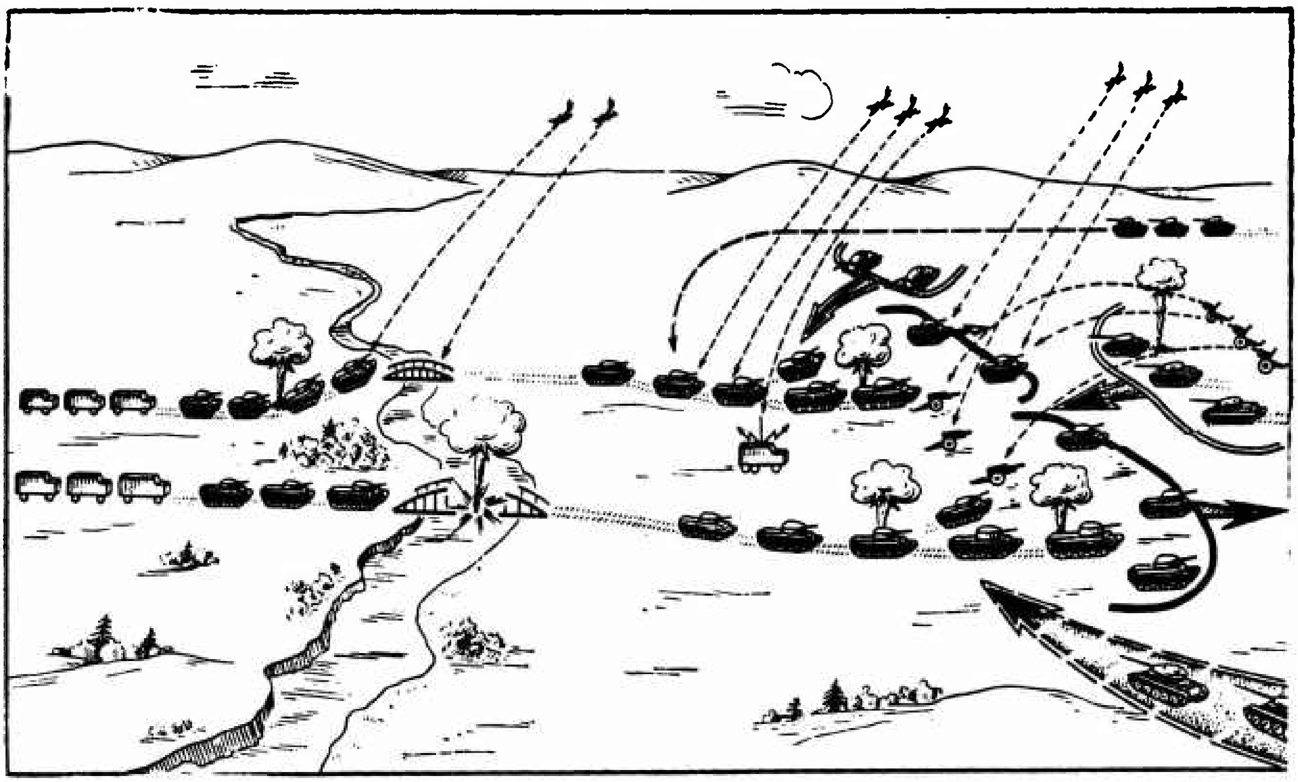


Figure 6.4.7. Delivering Fire on the Enemy in a Meeting Engagement While the Adversary Is Advancing and Deploying (according to the views of armies of capitalist countries)

In a meeting engagement of tank subunits under present-day conditions, an important role is played by seizure of an advantageous position by a portion of one's forces and a suprise attack by the main forces in the flank or rear. The lead subunits seize a position which is advantageous for holding in the path of the advancing enemy force, secretly deploy in this position, and hold the enemy with surprise tank and ATGM fire.

If a subunit is supported by artillery, the latter delivers fire on the enemy taking into account the specified plan of action. Based on the experience of the past war, surprise artillery fire in combination with intensive tank fire is especially effective when, because of terrain conditions, it is difficult for the enemy to maneuver or to deploy rapidly. An exceptionally important role was played by tank ambush actions. By delivering fire from the flank and rear from ambush, they could not only inflict heavy losses on the enemy but also confuse and disorganize him, which should immediately be exploited by the main forces to accomplish his complete defeat.

When seizing positions the terrain ahead of which impedes the actions of enemy forces, efforts were made to ensure that terrain behind friendly forces permitted deployment of the main forces rapidly and without being observed by the enemy.

The experience of combat operations of tank units and combined units in the Great Patriotic War demonstrated the high degree of effectiveness of hitting the enemy continuously, from the moment of detection on.

The main forces would initiate the assault, utilizing the actions of the covering force, usually from behind their flank. They would attack after hitting the enemy with artillery and supporting airstrikes. The enemy would initially be hit with fires as he approached the contact area, calculated not only to hit the enemy but also to hinder his maneuver and delay his advance. The enemy would usually be hit as his columns were crossing defiles, rivers, wooded areas, and passes. As a result of such strikes, the enemy's advance would be considerably delayed. Under present-day conditions, according to existing views in a number of armies of capitalist countries, the delivery of nuclear and conventional fires looks approximately as is schematically presented in Figure 6.4.7.

From the experience of the war, the greatest density of fire for effect on the enemy occurred at the moment the main forces were commencing the assault. There, depending on the time during which the enemy was delayed, the main force tanks would advance onto those axes where they could take up the most advantageous positions for an assault in mass and attack the enemy before he could bring his troops into a state of combat readiness. The pace and sequence of advance of friendly troops would be adapted to the time and capabilities of delivery of decisively effective fire on the enemy by air and artillery.

According to the views of foreign military experts, main forces can hit the enemy in a meeting engagement either simultaneously or sequentially.

It is believed that in a situation requiring considerable force of initial attack, a simultaneous attack by the majority of available troops is employed. This is achieved by moving up the required quantity of forces to the assault initiation line, timing things so that they are ready to attack on their axes by a specified

time. In a situation where the element of surprise can be achieved by concealing the advance and deployment of troops, and where time for organizing troop actions is limited, the attack can be executed sequentially -- as troops comprising the attack echelon arrive. Such actions are considered particularly advantageous in conditions where the adversary is advancing in a noncompact force, is delayed in moving up his forces, while his weapons have not yet deployed for combat.

According to views existing in the U.S. Army, in a meeting engagement a division's leading brigades move out onto their axes, sequentially deploying from march into combat formation. When a brigade is proceeding along a single route, lines of deployment into battalion, company, and platoon columns can be designated.

When friendly forces are engaging upon arrival, the division or brigade attacks with its forward units without initially halting. With this version, march groups (tank or motorized infantry battalions) proceeding at the heads of columns attack in the forward echelon. The remaining forces are engaged as they arrive. This version is specified in cases where superiority over the enemy will be achieved by artillery and airstrikes.

In the past war various actions were employed upon encountering an enemy force which was superior in men and weapons. If, for example, the enemy force was temporarily demoralized by artillery and airstrikes, the troops would engage this enemy force from march formation and commence the assault immediately. If this did not appear possible, an advantageous position would be selected, from which the enemy would be delivered fire from position, after which the troops would commence the assault. These actions were especially successful when opening fire on the enemy with the element of surprise.

According to views existing in the U.S. Army, when conducting a meeting engagement when large enemy forces are encountered, division main forces initiate the attack following a brief halt, and not unit by unit, but simultaneously by the entire main forces. U.S. military leaders believe that with this version, division main forces will engage 2-3 hours following initiation of a meeting engagement by advance guards, while the employment of nuclear weapons is unquestionably the decisive factor in achieving victory in a meeting engagement.*

In the opinion of foreign experts, nuclear weapons will be employed in a meeting engagement in combination with maneuver of troops and with conventional weapons. The principal targets of nuclear strikes in a meeting engagement include offensive nuclear weapons, attack-echelon tanks, support echelon, and command posts.**

It is emphasized that in all cases tank subunits and units move swiftly in a meeting engagement. Tanks proceed at maximum speed during deployment and in the assault. They choose the shortest routes when advancing. They utilize all advantageous topographic features during movement -- terrain irregularities, hills, brush, and ravines. No pauses or halts are permitted. Tanks deliver the greatest intensity of fire during the assault. Artillery does likewise, hitting tanks and other enemy targets, and especially antitank weapons. Air defense weapons cover

* See "Sukhoputnyye voyska kapitalisticheskikh gosudarstv," page 205.
** See ibid., pp 205-206.

the attacking tanks, repulsing hostile air attacks and destroying the enemy's ATGM armed helicopter gunships. Tank subunits achieve the greatest succcess in the initial attack by swift penetration of the enemy's battle order and by hitting the flanks and rear. The forces operating during this time on the axis on which the enemy is mounting the main attack block him and prevent him from maneuvering to the axis of advance of the main forces.

Based on the experience of the past war, in a meeting engagement the main forces usually would not hold back to complete mopping up individual pockets of resistance; they would swiftly bypass them and advance to depth without a halt, in order to split up the enemy as quickly as possible and destroy him piecemeal. The minimum requisite forces would be assigned the mission of repelling attacks by small enemy forces under these conditions.

By virtue of the fact that a meeting engagement of tank subunits and units, with both sides persistently endeavoring to achieve superiority and to force the adversary to give up continuation of assaults, is distinguished by exceptional intensity, all personnel in the course of a meeting engagement must display genuine boldness, daring and ingenuity. As an example of such actions, one can cite the engagement of the XVIII Tank Corps in the Battle of Kursk at Prokhorovka in July 1943.

Approximately 400 tanks clashed on a two-kilometer frontage in the zone of advance of the 181st and 170th Tank brigades, following a 15-minute Soviet artillery bombardment. The fighting continued all day on 12 July, with variable success. Toward evening about 60 German tanks frontally counterattacked subunits of the 181st Tank Brigade and the 32d Motorized Rifle Brigade, and up to 20 tanks, supported by self-propelled guns, attacked them from the rear. The 181st Tank Brigade and the 32d Motorized Rifle Brigade were forced to repulse the enemy attack with stationary fire. Receiving intensive resistance, the enemy was halted, and then pushed back to his initial position.

During the day of fighting the corps destroyed 63 enemy tanks and self-propelled guns, 28 antitank guns, killed more than 1000 officers and men, shot down five aircraft, and smashed 29 trucks carrying supplies and motorized infantry. The corps lost approximately 25-30 percent of its tanks. The XVIII Tank Corps fully retained the initiative in the course of the engagement. Successful actions by the units of the corps were promoted by close and continuous coordination on the part of all personnel and weapons. For example, when enemy tanks counterattacked units of the corps forward echelon from the rear, they were hit by the 110th Tank Brigade of the support echelon.

In a number of instances the adversary can offer the most stubborn resistance and, redeploying its forces, delay the advance of tanks. In order to prevent slowing of the rate of advance in a meeting engagement, foreign military experts recommend that pressure on the enemy be built up by engaging reserves, as well as by maneuvering men and weapons from one axis to another. It is noted that on the one hand promptness of engaging reserves was of particular importance for achieving the greatest result, while on the other hand it was important to take aggressive measures to thwart engagement of the enemy's reserves, such as by cutting them off from the main forces with airstrikes, artillery fire and resolute assaults.

Promptness of engaging reserves was defined as that moment in combat when forward-echelon forces were clearly insufficient to alter substantially the status of the opposing sides and to exploit offensive success (or hold occupied positions). Delay in engaging reserves under these conditions could lead to loss of initiative. In a number of instances reserves were committed to repel a sudden threat of enemy attack from the flank or rear.

As we know, premature utilization of reserves in combat is potentially dangerous. When maximum intensity in combat has not yet been reached, and the opposing sides retain the capability to fight successfully not only by committing reserves but also with effective actions by forward-echelon forces, retaining their reserves, there is a possibility of obtaining substantial advantages for subsequent exploitation.

According to views in the foreign military press, reserves in a meeting engagement are moved secretly and engaged with the element of surprise, on that axis where the greatest success can be achieved. Reserves are usually engaged on the flanks or in gaps in the forward-echelon forces. It is considered inadvisable for reserves to be engaged by leapfrogging past the forward-echelon dispositions, since this leads to excessively dense packing of forces and the threat of mixing troops. especially advantageous conditions were created when reserves were engaged on an enveloping flank to attack the enemy from the rear. At the same time, in a situation where the enemy was already split up by efforts of the attack echelon, reserves would be engaged along the shortest path, in order to complete crushing the enemy piecemeal as quickly as possible, swiftly attacking that force grouping designated to be destroyed first.

Engagement of reserves is supported by artillery fire and airstrikes on the opposing enemy force both forward of the line of contact and on the flanks of the forces being committed to battle. At the same time the forward-echelon troops operating on the axis of engagement of the reserves also deliver fire on the enemy and execute a swift assault.

Success achieved by engaging reserves would immediately be exploited by the attack-echelon forces. At the same time, in all cases a portion of forces of the forward-echelon troops would replace expended reserves in order to restore them to strength.

As noted above, meeting engagements and encounter battles usually take place between equal forces. However, in connection with the specific situation features, and particularly its vagueness, they may also occur in the absence of equality of forces, that is, with a superior adversary. For example, on 11 August 1943 the 1st Tank Army, with 260 tanks, encountered south of Bogodukhov counterattacking troops of the enemy's III Panzer Corps, with approximately 360 tanks. Savage fighting continued throughout the day. Part of the forces of the corps (forward brigades) advanced deep -- to the vicinity of Kovyagi. As a result of the encounter battle, the main forces of the corps, although unable to exploit the success of the covering forces and to soundly defeat the superior enemy, nevertheless did succeed in delaying him.

In the course of this battle the army's VI Tank Corps attacked the flank of the enemy's 2d Panzer Division in the vicinity of Vysokopol'ye and Aleksandrovka. The corps' 112th Tank Brigade succeeded, with a bold maneuver, exploiting a gap in the enemy's dispositions, in reaching an advantageous position ahead of the adversary, in attacking the latter with the element of surprise, from march formation, and inflicting heavy losses.

With favorable situation conditions, especially when the element of surprise can be achieved in attack on the enemy's main forces, greater success can also be achieved in a meeting engagement against a superior enemy force. In addition to the element of offensive surprise, it is based on beating the adversary in delivering fire, deployment and commencing the assault, and splitting up the enemy force.

The excellent maneuver capabilities and considerable striking power of tanks enable them to split up an opposing enemy force in short order and quickly concentrate principal efforts on crushing the enemy piecemeal. Such, for example, were the actions of the 4th Tank Army south of Kielce in January 1943. Provided frontal cover by two brigades, the army's troops executed a close envelopment from two sides on the enemy's 17th Panzer Division which had driven forward, and attacked it on two flanks. As a result, by the evening of 13 January the enemy division was routed. Subsequently the enemy's 16th Panzer Division reached the battle area, and was blocked frontally by the 49th Mechanized Brigade, while the main forces of the 4th Tank Army attacked the enemy division in the flank and surrounded and destroyed it on 15 January.

Abrupt and rapid situation changes in a meeting engagement and a swift drive by tanks to the enemy's flanks and rear frequently can lead to a situation where part of the forces may be separated from the remaining troops, and sometimes end up surrounded. In such a situation a decisive role is played by bold, resolute actions by the personnel of isolated units and subunits. In the past war, for example, the 61st Guards Tank Brigade, in combat as an element of the X Tank Corps against the German-fascist 17th Panzer Division in January 1943, found itself cut off from the rest of the corps forces behind enemy lines. It continued fighting heroically, however, and when the corps main forces initiated the assault phase, it attacked the enemy from the rear and thus helped complete the rout of the enemy.

Modern combat operations are conducted continuously, including at night. Meeting engagements are no exception. In particular, it is especially stressed in the foreign press that under conditions of increased power and capabilities of weapons and improved tank performance characteristics, their operations will be most aggressive precisely at night.

The specific conditions of the hours of darkness make it possible to operate concealed and to achieve the element of offensive surprise. Foreign experts believe that in a number of instances it is possible at night successfully to perform complex missions even with less forces than during the day. It is believed that since it is more difficult at night to determine the actual quantity of personnel and weapons of the opposing side, mounting of surprise attacks at night may sometimes produce greater results than during the day.

At night it is more difficult to gain bearings, to conduct observation, and to adjust the time and place of execution of actions. Therefore night vision devices are employed in conducting night actions.

Night movements are executed following the shortest route. A complex maneuver requires extensive employment of navigation gear, enabling the troops accurately and rapidly to reach the required axes and positions even in the absence of clearly visible landmarks.

An especially important role in night operations is assigned to precisely organized mutual recognition and marking of friendly troops. Essential in the course of tank night combat is continuous and more frequent information on situation changes than during day operations.

In the course of a meeting engagement, primary importance is attached to combating helicopter gunships, including those armed with ATGM. Success of these efforts in the course of a meeting engagement depends on thorough organization of air defense and skillful employment of air defense weapons, as well as prompt detection of helicopters before and during combat.

For combating helicopters in the course of a meeting engagement, it is recommended that air defense weapons be maintained continuously in the tank dispositions. weapons capable of quickly downing enemy helicopter gunships and fixed-wing aircraft as rapidly as possible. This is due to the fact that the short time required by a helicopter to accomplish its mission, amounting to only 40-50 seconds, for example, operating from ambush, unquestionably makes it more difficult to detect and destroy a helicopter, because a helicopter should be destroyed or measures taken to diminish its effectiveness precisely during this short period of time.

Thus tank meeting engagements are distinguished by a high degree of complexity and intensity. It is precisely in these engagements, however, that the tank's principal performance characteristic is revealed to the greatest degree -- considerable striking power, a result of the tank's great firepower and mobility.

Chapter 5. THE OFFENSE

1. General Considerations

Every tank commander should know that war is conducted according to objective laws characteristic of war, which are defined as the most general, essential and persistent relations which recur in the phenomena of war. The general laws of warfare include those which express the relationship between the course and outcome of war on the one hand and the correlation of economic, scientific, moral-political and military forces proper of the warring nations and coalitions on the other, as well as the character of their political aims.

Alongside general laws, there are laws which operate in the course of war which apply to the specifics proper of war -- armed combat. These are laws which reflect the all-encompassing, objective, intrinsic, necessarily stable relations which characterize the specific processes of armed combat, which is the principal content of war.

Many centuries of combat experience teaches us that victory is achieved through attack. Only by advancing forward, by destroying and capturing the opposing adversary is it possible to achieve decisive objectives and to force the enemy to surrender. Therefore in all the armies of the world the offense is considered the principal type of combat actions.

Under present-day conditions troops, including tank troops, can also conduct other types of combat actions which are variants of the offense and defense: meeting engagements, pursuit of a retreating enemy, river-crossing operations, repelling counterthrusts and counterattacks, etc. The offense and defense, however, constitute the foundation on which all troop combat activities are grounded. This proceeds from the fact that the attack and repelling the attack, or offense and defense -- are two dialectically interlinked processes of armed combat. They cannot exist in isolation, one without the other. In addition, elements both of the offense and of the defense are always present in each of these types of action.

It is believed that the enemy can be totally routed only with a resolute offensive, employing all the power of available forces and weapons. Offensive actions most of all promote retention of tank battleworthiness, under conditions of employment of modern weaponry and successful combat against enemy nuclear weapons.

The following principal and most characteristic modes of tank actions in a modern offensive battle are examined abroad: delivery of fire and forward movement, with the delivery of fire the principal mode of action, the basis of the offensive, for only with the employment of all types of weapons can heavy losses be inflicted on the adversary, taking away his capability to employ his weapons.

Foreign military experts believe that modern offensive operations of tank troops are characterized by even more decisiveness of objectives than in the past, and a sharp increase in the spatial scope; by employment of nuclear weapons as the decisive and principal means of hitting the enemy in order to achieve the stated objective; by unification of efforts with motorized infantry, air, airborne assault forces, other forces and weapons participating in battle; by the high mobility and maneuverability of the tanks waging combat; by the intensity and short duration of combat, by the diversity of methods of hitting the enemy employed by tanks and rapid shifts from one method of action to another; by abrupt and rapid situation changes; by the element of surprise in combat actions and constant effort to seize the initiative; by heavy expenditure of materiel and the possibility of massive casualties and combat equipment losses; a continuous high state of tank combat readiness to perform any missions which may arise on the basis of the situation.

Foreign experts comment on the points enumerated above as follows.

The decisiveness of objectives and large spatial scope of the offense are based on the possibility of swiftly crushing the adversary with massed employment of nuclear weapons, on fullest utilization of the increased range of weapons, mobility and maneuverability of tank subunits, and on the driving skill and excellent combat proficiency of tank crews. Failure to observe these demands is fraught with serious consequences.

Employment of nuclear weapons as a decisive and principal means of hitting the enemy is new and determining in successful accomplishment of missions by armored troops and rapid achievement of their objectives. Nuclear weapons and the principal means of delivering them to the target -- missiles, which combine enormous power and great range on the battlefield, enable tank subunits under present-day conditions rapidly to accomplish missions which are the most diversified in character and scale.

Mutual support between tank subunits and motorized infantry, air, airborne assault forces, as well as other forces and weapons participating in combat ensures the success of an offensive. In spite of the fact that a decisive role in combat operations will be played by nuclear weapons, victory can be achieved only by the joint efforts of all combat arms and aviation, in uniting efforts with other services working in cooperation with tanks.

Mounting of deep and swift attacks by tank subunits to the entire depth of enemy dispositions, based on employment of nuclear weapons and high mobility actions of tanks working in coordination with other troops participating in combat, is one of the conditions for rapidly achieving decisive objectives and a large spatial scope of the offensive operation.

Hitting the enemy's principal forces to the entire depth of his dispositions with missile and airstrikes, in the opinion of foreign military experts, opens up considerable possibilities for successful actions by motorized infantry subunits, deep, swift tank attacks and landing of airborne assault forces with the aim of swift completion of defeat of the enemy and capture of his most important areas and installations.

The element of surprise is of decisive significance for offensive success. Surprise is achieved by deception, by deluding the adversary, and by concealment and camouflage.

Military leaders of old pointed to the necessity of utilizing the element of surprise; they stated that in war it is necessary to outwit the enemy.

Aggressiveness and persistence in pursuing objectives constitute one of the features of offensive tank operations. Aggressiveness is closely linked with initiative. He who holds the initiative is the master of the offensive situation.

Continuous conduct of combat actions is one of the most important conditions for achieving offensive success. Initiated actions should be conducted aggressively and continuously, day and night, at any time of the year, in any weather, until the enemy is totally defeated.

Of importance for offensive success is selection of the main axis of advance, which comprises an aggregate of nuclear strikes and swift advance by tanks and other ground troops subunits in coordination with these nuclear strikes.

According to the experience of the past war, main axis of advance is defined as that direction of combat actions in which the main efforts of the attacking force are concentrated in order to accomplish the principal offensive missions.

In the opinion of foreign military experts, main axis of advance presupposes the most expedient employment of nuclear and other weapons and exploitation of the results of delivered fire by advancing tanks in order to achieve rapid defeat of the main enemy force; swift advance by attacking troops to considerable depth; their rapid advance into areas subjected to nuclear strikes, in order to complete the rout of the enemy or seize important areas and installations. The success of an attack is ensured by establishing and continuously maintaining on the main axis of advance a superiority in men and weapons, especially nuclear weapons.

This is achieved by concentrating the principal efforts of missile subunits and air to destroy the enemy's offensive nuclear weapons and principal force groupings; by establishing a battle group consisting primarily of the most battleworthy tank subunits, with strict observance of the demands of dispersed disposition of personnel and weapons in order to protect them against enemy nuclear weapons; by prompt build-up of troop efforts by executing extensive maneuver by tanks and other weapons in the course of offensive actions.

It is believed that the axis of advance of tanks under present-day conditions should ensure maximum utilization of their maneuver capabilities, as well as gaps in the enemy's dispositions, areas covered by negligible forces, for rapid penetration deep into the enemy's dispositions.

Conduct of offensive operations in the absence of continuous battle fronts, on separate axes and simultaneously at differing depth, it is believed abroad, constitutes one of the specific features of a tank subunit attack under present-day conditions. The character of such tank actions is dictated by considerable capabilities to inflict damage on the enemy with nuclear weapons, which make it possible to put out of commission not only individual units but also large force groupings, as well as by the high degree of mobility and maneuverability of tanks.

Concentration of tanks on decisive axes assumes even greater importance for today's offensive actions than in past wars. The conditions and procedure of massing tanks, however, differ substantially today from similar actions in the past. It is believed that under the new conditions there is no need to maintain a compact formation, since decisive significance for achieving success in combat actions is assumed primarily by massed employment of nuclear weapons and other weapons on the main axes for hitting the enemy's main force groupings and most important targets, as well as maneuver and swift actions by tanks following these attacks, with maximum concentration of large battle groups. Dense formations and massing of troops are inadmissible today. Personnel and weapons must be dispersed to the greatest possible extent for the successful conduct of combat actions, and particularly in order to create facorable conditions for their rapid utilization on decisive axes, against the principal enemy targets and at an appropriate time.

The high mobility of tank actions is a characteristic feature of today's offense.

It is believed that highly mobile actions, which ensure continuity and a high rate of advance, are most fully manifested in tank actions from march formation. Such actions consist in the fact that preparation of tank subunits to perform a forthcoming mission is accomplished during performance of preceeding missions without any halts or pauses in combat operations.

Highly mobile tank actions are grounded on prompt and full utilization of the entire power and range of nuclear missile weapons and conventional weapons, as well as the high mobility of missile subunits and aviation, air defense forces, other forces and weapons involved in an offensive operation. Therefore organization and execution of nuclear strikes in the shortest allowable time for accomplishing the principal missions, conduct of an attack by tank subunits following these strikes at the greatest possible speed, prompt advance and displacement of all other forces and weapons with utilization, when necessary, of the maximum march capabilities of all troops, as well as their rapid deployment and shift to other formations in conformity with the developing situation will constitute the content of high-mobility actions under present-day conditions.

Proceeding from the above, it is believed that tank combat operations should be conducted continuously, day and night, and should be characterized by a high degree of mobility and a highly dynamic character.

Tank subunits, swiftly advancing following nuclear strikes, exploit without delay the results of these strikes. They should be able rapidly to organize and deliver fires with their own weapons, without halting the advance, and they should be capable of rapidly deploying on command (signal) from columns into approach march or combat formations, of swiftly attacking the enemy and, when the enemy has been crushed, of rapidly deploying into columns.

The short duration of battles is predetermined by the capability of modern weapons, and chiefly nuclear weapons, of almost instantaneously delivering massive effective fire on the enemy and knocking out entire elements and important targets, and also by the capability both of ground troops as a whole and their striking power -- tanks -- of rapidly exploiting the results of nuclear strikes and completing the rout of opposing enemy forces.

Modern tank offensive operations will also be characterized by an increased element of surpise and a fight to seize the initiative in all types of combat actions.

Successful accomplishment of offensive missions depends on correct selection of mode of passing to the offensive.

2. Modes of Passing to the Offensive

An analysis of foreign military literature indicates that with modern means of delivering nuclear warheads to the target, it is possible to neutralize and destroy entire force groupings as well as to destroy important enemy installations to their entire depth of disposition in a theater of military operations. All this significantly affects not only the modes of passing to the offensive but also the course and outcome of combat actions.

The term mode of passing to the offensive is defined under present-day conditions as the procedure of delivering powerful air and artillery strikes on the enemy and the character of actions of the troops proper which follow these strikes.

Modes of passing to the offensive by tank subunits, in the opinion of foreign authors, depend on the situation conditions and will be determined in each concrete instance by the degree of neutralization of the enemy, and particularly his offensive nuclear weapons, as well as by the character of actions of his troops, the state, position and combat capabilities of the tank subunits of the attacking force at the moment of passing to the offensive.

It is believed that there can be several methods of ground troops, and especially tank forces, passing to the offensive. In the opinion of foreign experts, however, the greatest preference should be given to a method whereby surprise, massive fire delivered on the opposing enemy force is secured, with prompt exploitation of the results of this fire by tanks in order to penetrate swiftly deep into the enemy's dispositions.

Under present-day conditions, attack of a defending enemy force may be executed directly from march formation as well as from close contact with the enemy. Under conditions of employment of nuclear weapons, the attack directly from march formation is considered the principal offensive mode. Tanks and tank subunits will pass to the offensive primarily on those axes on which the enemy has been most heavily damaged by nuclear strikes and delivery of conventional fires. Passing of tanks to the offensive directly from march formation ensures their rapid advance into the areas where the principal offensive nuclear weapons are located and a swift advance deep into the enemy's rear.

Deep in the enemy's defense, an attack without a halt in attack position may begin directly from the march and even in columns. For passing to the offensive by tanks in columns without deploying into combat formations under present-day conditions, intervals and gaps between the enemy's operating troops can be extensively utilized.

At the same time it is stipulated that if for various reasons it is impossible on certain axes to deliver reliable, effective fire on opposing enemy forces, tank subunits will pass to the offensive with deployment of tanks into combat formation without a halt in attack position. Such a procedure enables tank subunits quickly to seize and hold the initiative at the very outset of action, to thwart an enemy advance on a given axis, to destroy or capture the enemy's principal missile weapons, and to disrupt the operations of his rear services. Operating in coordination with missile subunits, air, motorized infantry and airborne assault forces, the tanks should advance swiftly in columns, smash the enemy's reserves, thwart deployment of fresh enemy forces, and thus ensure that all attacking troops achieve their objectives as quickly as possible.

In those cases where the enemy, although fairly well neutralized, can offer resistance and threaten delay of the advancing troops, in order to avert this threat it is recommended that a portion of the attack-echelon forces of the advancing tank troops be deployed into combat formation, while maintaining support echelons in columns or lines. But if the opposing enemy force is not neutralized and offers substantial resistance, the advancing tank subunits will be compelled to deploy into combat formation and attack the enemy with artillery and air support.

Thus under present-day conditions, according to the views of foreign experts, passing of tanks to the offensive without a halt in attack position is possible in the following instances (Figure 6.5.1):

following nuclear strikes in columns or approach march formation without deploying the main force grouping into combat formation;

following nuclear strikes, in a combined mode, where a portion of the tanks passes to the offensive in columns or approach march formation, while the remainder deploy into combat formation for passing to the offensive;

following nuclear strikes, with deployment of the main tank force into combat formation and preliminary bombardment by conventional weapons.

It is believed that with tanks passing to the offensive in columns or approach march formation, tanks are able promptly and most fully to exploit the results of nuclear strikes by advancing swiftly along the shortest routes to depth, with tanks and infantry combat vehicles delivering fire directly from columns, and only when necessary assuming combat formations to knock out individual pockets of resistance.

Passing of tanks to the offensive with deployment of the main forces into combat formation without a halt in attack position can be a forced mode of action with inadequate damage inflicted on the opposing enemy force (Figure 6.5.2). Under these conditions lines of deployment into combat formation beyond minefields are designated.

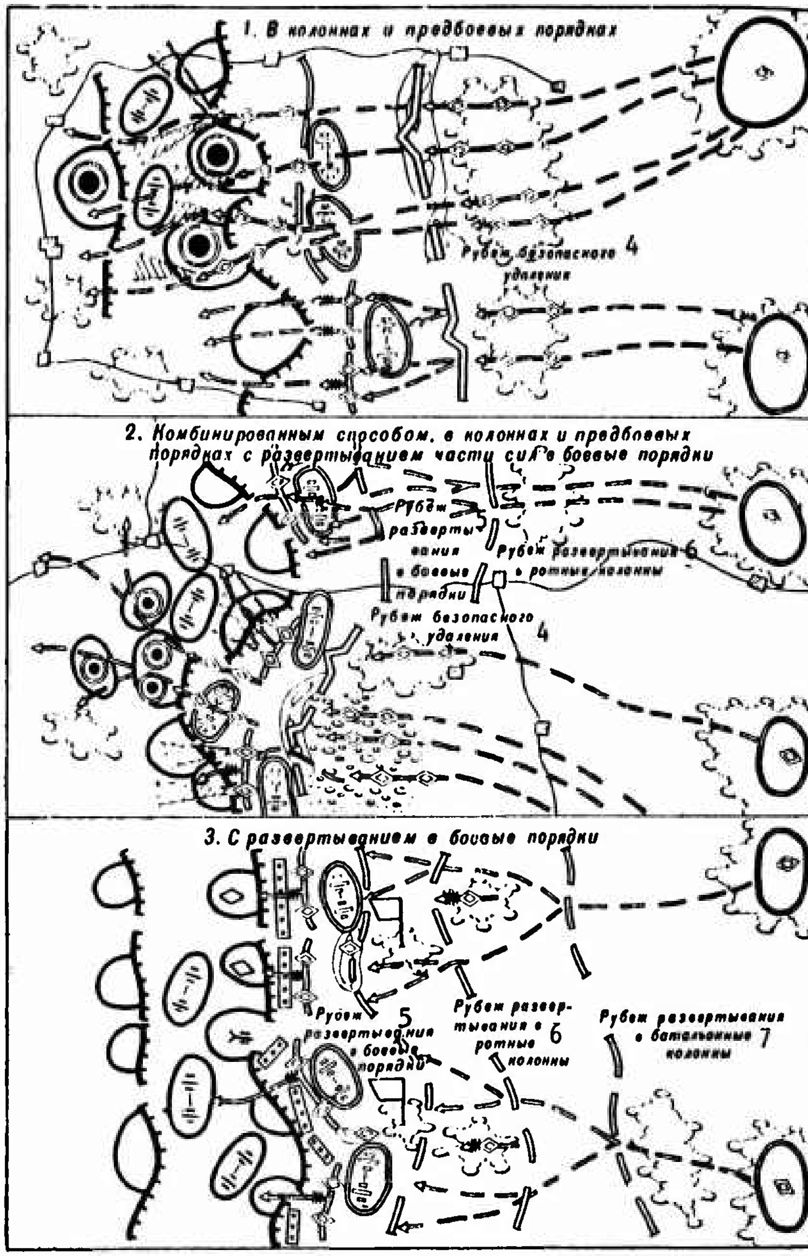


Figure 6.5.1. Possible Modes of Tanks Passing to the Offensive

Key:

1. In columns and approach march formation
2. Combined mode, in columns and approach march formation with deployment of part of the forces into combat formations
3. With deployment into combat formations
4. Risk distance line
5. Line of deployment into combat formations
6. Line of deployment into company columns
7. Line of deployment into battalion columns

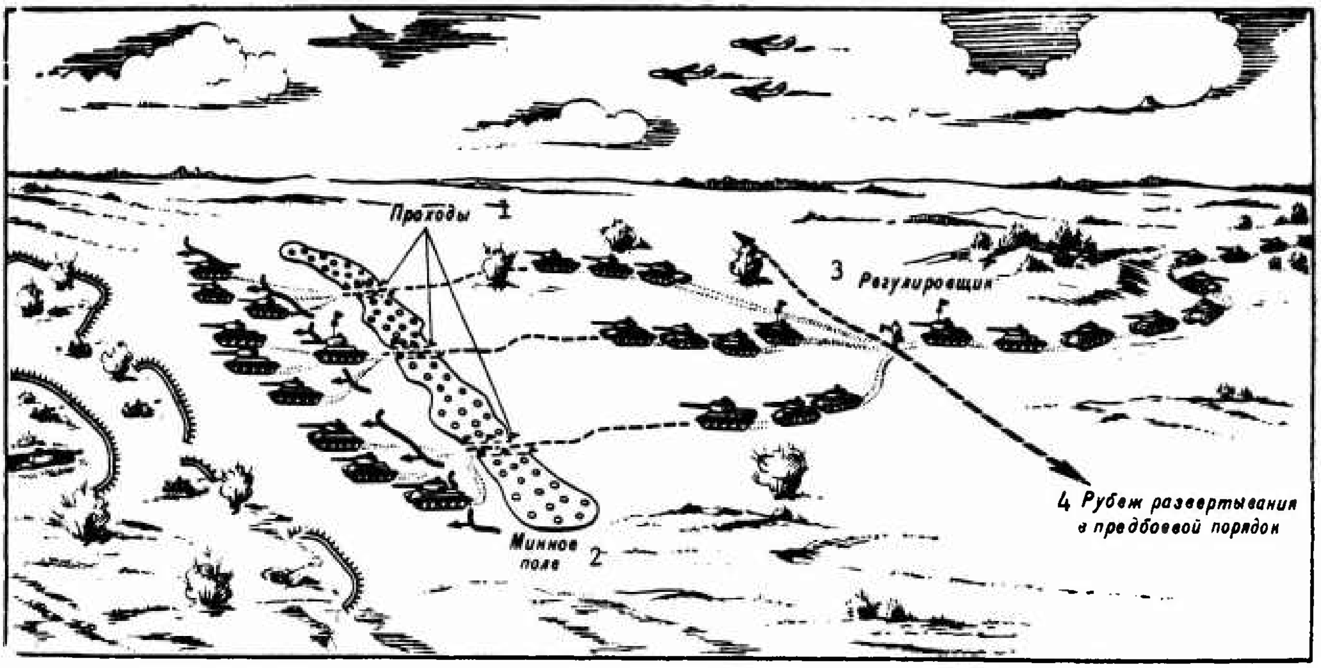


Figure 6.5.2. Tanks Passing to the Offensive With Deployment of the Main Forces Into Combat Formation Without a Halt in Attack Position, Beyond Enemy Minefields (variant)

Key:

1. Lanes
2. Minefield
3. Traffic controller
4. Line of deployment into appproach march formation

Tanks operate in combat formations when attacking a defending enemy force from close contact with that force.

3. Conduct of the Attack

It is noted in the foreign press that attack of a defending adversary begins with penetration of his defense, with delivery of fires with employment of all available weapons, and a subsequent resolute assault by tank and motorized infantry units.

With conduct of an attack without a halt in attack position, reconnaissance and engineer subunits, advancing to the enemy's defenses ahead of the main forces, immediately proceed to reconnoiter the enemy's defensive fortifications and to determine the character of his obstacles, particularly minefields. Lanes are cleared through obstacles (minefields) and are clearly marked for tank passage. Tank platoons cross minefields by these lanes and then deploy for the assault. After artillery fire and airstrikes are shifted from the forward edge of the battle area, tanks with motorized infantry penetrate the first position and exploit the advance deep into the enemy's defenses and toward the flanks.

Tank troops which have passed to the offensive continue advancing in those formations in which they commenced the attack: in columns, approach march or combat for-

formation, but in the course of advancing to depth and toward the flanks, combat formations change in conformity with actions taken by the enemy.

In conditions where there lie in the path of tank subunits areas of terrain with substantial radiation levels, and where detouring around these areas will be impossible for any reasons, it is recommended that commanders at all echelons replace the subunits which have been operating in these zones. Figure 6.5.3 shows the sequence of actions of a tank company in crossing terrain with substantial levels of radioactive contamination.

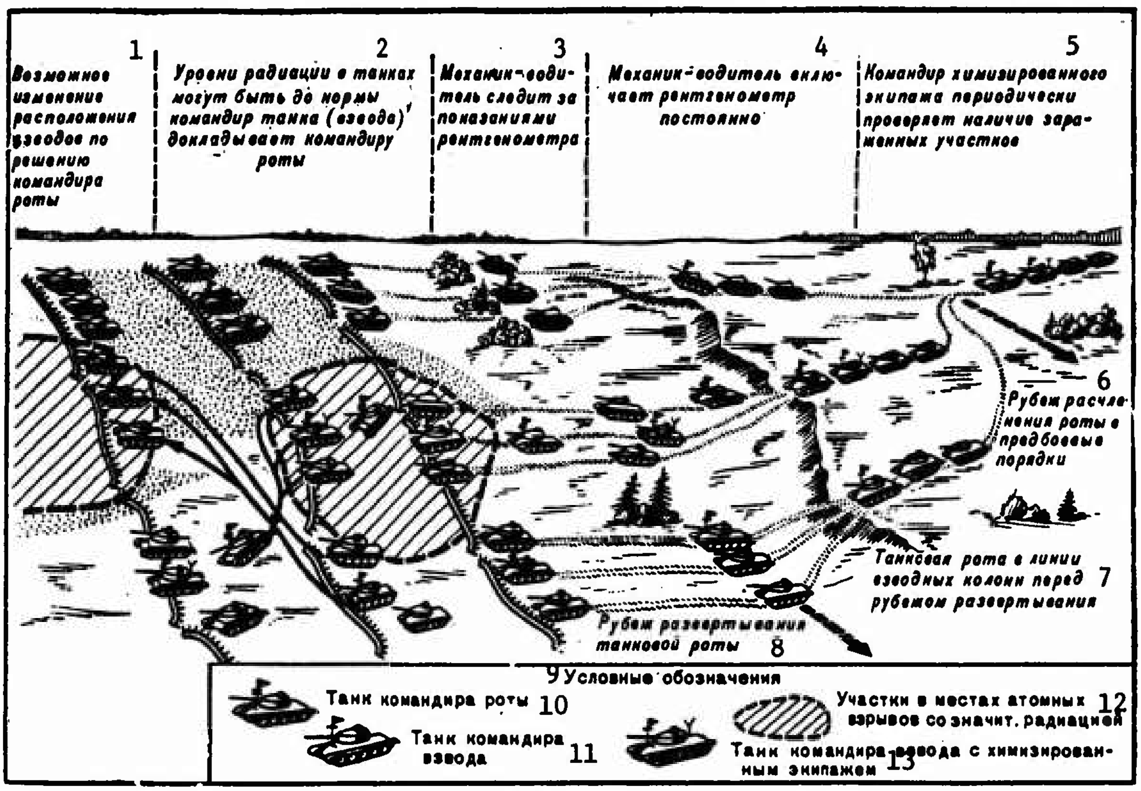


Figure 6.5.3. Sequence of Actions by Tanks in Crossing Terrain With Substantial Levels of Radioactive Contamination

Key:

1. Possible change in disposition of platoons by decision of the company commander
2. Radiation levels in tanks may reach a specified level; the tank (platoon) commander reports to the company commander
3. Driver monitors dose-rate meter
4. Driver switches on dose-rate meter and leaves it on
5. Commander of crew subjected to decontamination periodically checks for presence of contaminated terrain
6. Line of company split into approach march formations
7. Tank company in line of platoon columns before reaching deployment line
8. Tank company deployment line
9. Legend

(Key to Figure 6.5.3 cont'd from preceeding page)

10. Company commander's tank
11. Platoon commander's tank
12. Areas at locations of nuclear bursts with substantial radiation
13. Platoon commander's tank with decontamination-treated crew

---

Foreign military experts consider the following forms of maneuver by tank troops in the attack to be the most acceptable.

Mounting of attacks on several shortest axes with the objective of splitting and destroying the enemy piecemeal ensures rapid disruption of the stability of the opposing enemy force, deep exploitation of the attack, and dispersion of the advancing tanks. In these conditions the enemy's attention is scattered, his efforts are spread, and it is more difficult for him to select targets for nuclear strikes and actions by his troops.

It is recommended that attacks on converging axes be employed for the purpose of encircling enemy troops and their simultaneous destruction. Such a form of maneuver was widely employed in the past war. It is believed abroad, however, that the enemy may employ nuclear weapons and mobile troops to counter encirclement. This can immobilize considerable attacking forces and can slow the tempo of tank advance to operational depth. It is also believed that it is advisable to employ maneuver to encircle the enemy in those cases where the enemy main forces are dispositioned in relatively small areas, while the delineation of the battle line and the nature of the terrain promote rapid advance of tanks in converging directions with simultaneous swift, deep exploitation, and therefore in order achieve rapid encirclement of the enemy it is advisable to destroy with nuclear weapons primarily the enemy's offensive nuclear weapons as well as hitting troops which are attempting with counterthrusts to impede completion of the encirclement maneuver. In addition, nuclear and conventional strikes are delivered and frontal offensive actions mounted against the encircled enemy force for the purpose of simultaneously splitting it up and destroying it piecemeal.

Alongside these basic forms of maneuver, in the opinion of foreign experts, turning movements and envelopments can be extensively employed in the attack for tanks to drive to the flank of the enemy main forces for the purpose of routing them. It is recommended that one extensively employ gaps, boundaries and poorly covered axes in the enemy's order of battle for penetrating deep into his dispositions. Tanks should attack on a broad frontage and to considerable depth. Only in this case is it possible to achieve decisive successes and to secure one's flanks. If terrain conditions force tanks temporarily to move closer together, they should more rapidly assume their previous combat formation.

In order to achieve a high rate of advance, tanks should endeavor to advance on the heels of nuclear strikes in columns or in combat formation, extensively exploiting gaps and poorly covered axes in the enemy's order of battle, to execute turning movements and envelopments in order for tanks to advance into the flank and rear of the enemy main forces with the objective of routing them.

Any method of destroying the enemy in an attack should be grounded on delivery of highly destructive fire, followed by a swift and deep tank advance. In those cases where possible, it is recommended that airborne assault forces be delivered to the enemy's rear.

During the exploitation phase, in the process of accomplishing their missions, tank subunits will frequently be compelled to destroy enemy reserve forces. It is important correctly to determine the method to be employed, ensuring decisive annihilation of these forces and creation of favorable conditions for further exploitation.

It is stated in the foreign literature that various methods of destroying enemy reserves can be employed in present-day conditions. Depending on the situation, in the course of offensive operations enemy reserves can be destroyed simultaneously or sequentially, on one or several axes.

The principal method of crushing enemy reserves in the course of an offensive operation is delivery of massed nuclear and conventional fires in combination with swift actions by tanks, completing the destruction of these reserves.

Annihilation of enemy reserves can be completed either immediately following nuclear strikes or in the course of the attack, when a portion of the tanks will be advancing swiftly forward toward the areas of nuclear strikes delivered at depth, while other tanks will be employed jointly with motorized and infantry units to complete the destruction of the remaining enemy troops. Depending on the results of nuclear strikes, completion of the annihilation of enemy reserves can be accomplished with or without the employment of nuclear weapons.

It is pointed out that troop actions to complete annihilation of the enemy can vary, depending on the degree of damage inflicted by nuclear weapons. In one case, such as with a high degree of damage inflicted on the enemy as a result of nuclear strikes, his annihilation will be completed by small forces, even separate detachments, while the main forces will be involved in deep exploitation. In another case, when the enemy is damaged by nuclear strikes to a lesser degree, annihilation of the enemy can be completed with a part of the forces, while the remainder will be engaged in deep exploitation. Upon completion of annihilation of the enemy, tank subunits as a rule will proceed with pursuit of surviving enemy forces.

4. Pursuit

Experience of employment of tank troops indicates that an attack becomes purposeless if it does not develop into pursuit. Two types of pursuit are differentiated -- frontal, and parallel. Only pursuit can consolidate success achieved in prior, often very stubborn fighting. Proceeding from this, each tank commander should endeavor to continue the attack with all battleworthy vehicles until the fuel runs out.

Tanks are an indispensable means of pursuit, since they can quickly neutralize or outflank an enemy who is offering resistance to the depth of his defense.

It is essential to shift immediately to pursuit as soon as offensive success has been determined and enemy withdrawal noted, day or night, at any time of the year, and in all weather. The hours of darkness should be utilized for continuing the attack. The strength of will of tank crews in this instance should not be less than the tirelessness of the tank engine. Only in this way is it possible to alleviate subsequent engagements or avoid them altogether. Armor commanders should in the pursuit operate according to the principle "Leave everything behind!" They should firmly be convinced, however, that they will be promptly reinforced and resupplied.

In the pursuit tanks can employ one of their principal performance characteristics -- mobility. The key to victory lies precisely in maneuverability and mobility.

During World War II pursuit was accomplished for the most part by mobile combined units. Pursuit was conducted both on a tactical and operational scale. Under present-day conditions, however, its role, character and scope are changing substantially. In large measure it will be necessary to organize and conduct pursuit in a new manner, applicable to the conditions of conduct of combat operations with employment of nuclear weapons.

Foreign authors note that, in contrast to the past, under present-day conditions the following situation is possible during the conduct of combat operations: as a result of massed employment of nuclear and nonnuclear weapons as well as resolute actions by tank and motorized rifle troops, tactical air and airborne assaults, the enemy's main forces will prove to be almost totally destroyed. Elements proceeding to retreat will not be organized enemy force groupings but isolated remnants, incapable of exerting significant influence on the course of combat operations. In these cases advancing tank subunits will essentially combine pursuit of the enemy with swift advance deep into enemy territory, exploiting the results of nuclear strikes.

Thus foreign experts have reached the conclusion that pursuit will be of even greater significance than in the past. This is due to the fact that with employment of nuclear weapons by both belligerents, each will receive considerably greater opportunities than in the past to conduct determined and deep offensive operations, forcing surviving enemy troops to retreat by means of swift attacks. In addition, a defending enemy can more frequently employ maneuver for the purpose of deliberate withdrawal than has been the case in the past, withdrawing his troops from attack by the advancing forces.

It is noted in the foreign military press that in the past war preliminary airstrikes and artillery bombardment in the conduct of an attack would neutralize the enemy's defense and disrupt the defense system within the tactical zone, creating favorable conditions for successful penetration, while today a massive nuclear strike, which may initiate combat operations, can lead to collapse of the enemy's entire defense. And the more effective this strike, the less capable the defending troops will be to fight for a given defensive line. Consequently the conclusion is reached that today pursuit can commence even at the very outset of offensive actions. And in the course of an attack, delivery of nuclear strikes simultaneously to the entire depth of the enemy dispositions and the swift advance of the troops of one of the belligerents also will force the opposing side to withdraw its

troops more frequently then in the past. Thus in many cases pursuit may prove to be the principal content of exploitation.

It is noted that massed employment of nuclear weapons and consequently fundamental changes in the objectives and charater of present-day offensive operations cannot help but affect the objectives and character of pursuit, its very essence. As we know, in the past pursuit comprised only actions by ground troops with air support, while today it also includes such a new and highly important element as delivery of nuclear strikes on nuclear weapons, enemy retreating troops and reserves. Airborne assault operations are today considered an inseparable component part of pursuit, and in coastal areas -- amphibious landing forces, working in coordination with swiftly advancing tanks. The decisiveness of pursuit objectives will inevitably increase in connection with this. Under present-day conditions, it is noted in the foreign press, the availability of nuclear weapons and other powerful weaponry makes it possible to inflict decisive damage on a retreating enemy with nuclear strikes and to complete annihilation of the retreating force with troops in the course of pursuit. Consequently, the aim of pursuit may be not only to create preconditions for subsequent destruction of a retreating enemy but also his annihilation proper.

We must note that in operations of the past war efforts were already being made to utilize the most powerful and mobile forces, tank armies, for example, in the course of pursuit in such a manner that they not become involved in drawn-out fighting with retreating troops and approaching enemy reserves but move swiftly to operational depth and reach those areas or lines seizure of which constituted the final objective of the operation. But at that time this was difficult to achieve, and pursuing forces were frequently drawn into battle with retreating enemy troops.

Under present-day conditions, however, it is believed abroad, tanks possess substantially greater capability not to become involved in drawn-out battles. Therefore the aim of pursuit can be not only to prevent withdrawal of enemy troops but also to reach as rapidly as possible areas and objectives seizure of which is the final objective of the offensive operation.

The conditions of occurrence of pursuit under present-day conditions, as is noted in the foreign military press, can be quite diversified. Pursuit can commence and be conducted during forced or deliberate enemy withdrawal. One assumes that pursuit of an enemy forced to retreat will commence and be conducted under more diversified situation conditions. The defending force may be compelled to initiate withdrawal as a result of effective employment of nuclear weapons by the attack force, that is, at the very outset of offensive operations.

It is noted that initiation of pursuit is also possible during exploitation, such as with successful employment of nuclear weapons against enemy reserves advancing from depth, during successful thwarting of enemy counterattacks and counterthrusts, or with an unsuccessful outcome of a meeting engagement for the enemy. Pursuit, begun as a result of the successful outcome of a meeting engagement, will become most typical, since meeting engagements proper will prove to be a more frequent phenomenon than was the case in the past, especially at the beginning of a war.

At the same time one cannot exclude the possibility of pursuit of a deliberately withdrawing adversary. Under conditions of extensive employment of nuclear weapons, the troops of that side which is unable to establish in a timely manner appropriate forces of nuclear weapons and ground troops will be compelled intentionally to withdraw. As we know, in such cases, as well as with clear enemy superiority, under present-day conditions it is considered possible to fight delaying actions in order to gain time, to redisposition reserves and to change relative strengths in one's own favor. Sometimes that side which possesses sufficient ground forces but which lacks the requisite quantity of nuclear weapons will be forced to resort to intentional withdrawal. A portion of the forces of an intentionally withdrawing adversary may remain sufficiently battleworthy, and therefore such an adversary will be able to offer determined opposition to pursuing tanks. This will also affect the nature of actions of tank subunits as a whole.

Thus pursuit may begin under the most diversified conditions. Conditions of conduct of pursuit will also be varied (depending on the physical-geographic and economic features of a given axis, the composition and character of actions of the withdrawing enemy force, as well as the capabilities of the opposing sides to employ nuclear weapons, etc).

Possession by the pursuing force of a sufficient number of tanks, nuclear weapons and missiles of various types, total motorization and mechanization of ground troops, employment of airborne assaults and capability to airlift troops with their weapons and combat equipment, and the possession of modern means of reconnaissance -- all this greatly increases, in comparison with the past, capability to conduct pursuit with more decisive objectives, to great depth and at a rapid pace.

Initiation of pursuit at once on a broad front, simultaneously or sequentially on several axes will be typical for present-day conditions.

Of particular importance is the question of tempo of pursuit. In order successfully to accomplish the missions of offensive operations which are of a determined nature and are of substantial depth, an exceptionally high rate of execution is essential. And since pursuit may comprise a large part of offensive operations, the overall rate of its conduct will also depend on the rate of pursuit.

A high rate of pursuit will make it possible to thwart the enemy's planned and orderly withdrawal and his occupation of previously prepared defensive positions, redeployment of reserves and their preparation for counterattacks and counterthrusts and, consequently, will in large measure promote achievement of the final objectives in the shortest possible time. In addition, of exceptional significance in a nuclear war is the fact that delivery of nuclear strikes and employment of other weapons will be greatly complicated for the enemy with a high rate of pursuit, since it will be necessary more frequently to change missile launcher positions, and reconnaissance and troop control will become considerably more complex.

Foreign military experts believe that an increase in the depth and width of frontage of pursuit in comparison with the past requires an increase in the number of troops for its conduct. Tank subunits and units can successfully operate independently in the course of pursuit at a considerable distance from the remaining forces, exploiting the results of nuclear strikes as well as gaps and intervals

in the enemy's dispositions. For most effective utilization of nuclear weapons and other modern weapons, however, it is advisable to enlist for the direct annihilation of the retreating adversary not all pursuing tank subunits but only whatever portion is necessary. It is recommended that the main forces continue advancing swiftly in order to achieve the final objectives of the offensive operation as quickly as possible.

Thus it is noted that pursuit under present-day conditions is assuming an even more resolute character and greater scope than during World War II. It would be incorrect, however, to ignore the increased capabilities of the opposing side. In the opinion of foreign military experts, the retreating force can also utilize nuclear weapons and other modern weapons to deliver strikes, including from deep in its dispositions, on the pursuing troops. In addition, in order to delay the pursuing force, the retreating force may deliberately establish in their path vast zones of physical destruction, flooding and radioactive contamination.

It is noted in the foreign press that a substantial increase in the quantity of various antitank weapons and a sharp increase in their effectiveness, as well as extensive employment of various artificial obstacles and physical destruction during retreat will greatly complicate the actions of tanks and tank subunits during pursuit. In addition, the retreating force may have modern means of reconnaissance at its disposal, which will make it difficult for the pursuing tanks to gain the element of surprise. It is also possible that the withdrawing troops and approaching reserves will mount strong counterattacks and counterthrusts against the pursuing troops, especially when the withdrawal is intentional. All this enables one to state that in the conduct of modern offensive operations pursuit will take place in more complex conditions than in the operations of World War II.

In past wars parallel pursuit was conducted most frequently by tank and mechanized troops. The main forces of the advancing troops, exploiting the successful actions of mobile troops, would advance behind them and conduct frontal pursuit, although they too would sometimes assign part of their forces to parallel pursuit. Experience indicated, however, that frontal pursuit alone cannot lead to decisive results, since it leads to "ejection" but not annihilation of the enemy. Therefore parallel pursuit, whereby advancing tanks overtake the retreating enemy, employing parallel routes, enables them to penetrate more rapidly to depth, to cut off the avenues of retreat of the main forces, to isolate them from deep reserves, to split them up, and thus to create favorable conditions for finishing them off.

Foreign experts note that under present-day conditions as well it is recommended that parallel pursuit, as the most effective, be considered the principal form of action for all ground troops, including tanks. However, in order for parallel pursuit to be more effective for frontally blocking a retreating enemy, it is recommended that parallel pursuit be combined with frontal pursuit.

It is believed that nuclear weapons and other modern weapons enable troops conducting frontal pursuit more easily to overcome the resistance of the enemy's covering units, to inflict casualties on his withdrawing troops, to force them to deploy and to slow the pace of withdrawal. It is pointed out that frontal pursuit should not boil down to frontal attacks. In the course of frontal pursuit it is recommended that the pursuing troops maneuver extensively, mount flank attacks on

the withdrawing enemy and, acting in coordination with the troops conducting parallel pursuit, encircle and destroy the enemy.

It is noted in the foreign press that nuclear weapons are the principal means of destroying withdrawing enemy troops. Nuclear strikes would be delivered on precisely determined targets: nuclear weapon delivery systems, airfields, main forces of withdrawing troops and reserves, especially during passage of defiles and during deployment or halts. In those cases where enemy reserves present the greatest threat to pursuit exploitation, it is recommended that they be targeted for nuclear strikes on a priority basis.

It is believed that forward units capable of operating independently, separated from the remaining forces, will be extensively employed in pursuit. Such units, in the opinion of foreign experts, should advance swiftly to positions and areas of tactical or operational importance and seize them.

It is believed that skillful employment of forward units consisting of tank subunits will make it possible more rapidly to exploit the results of nuclear strikes, to destroy rearguards and to cut the enemy's avenues of withdrawal, to seize important areas and installations, thus ensuring successful crossing of defensive lines and water obstacles by all tanks and other troops, to help split up the withdrawing enemy and his piecemeal annihilation. In addition, seizing road junctions and passes, forward units can promote the forced massing of the retreating enemy and consequently creation of favorable conditions for strikes by nuclear and other weapons.

This is a mission of forward units which is new in comparison with the past war. Another exceptionally important mission of forward units is advance to enemy missile deployment areas and airfields, capture or destruction of enemy launchers and aircraft.

In order that forward units can successfully accomplish such missions in the course of pursuit, it is recommended that they be made strong but not unwieldy; otherwise they will lose their advantages in mobility and speed of movement in comparison with attack-echelon troops. Therefore it is considered most advisable to employ in forward units tank subunits reinforced by artillery and motorized infantry.

It is noted that it is especially advantageous to send forward units out from troops conducting parallel pursuit, since in this case favorable conditions are created for even faster and deeper advance by these troops into the rear of the retreating enemy.

Airborne assault forces of various role, delivered for the purpose of disorganizing the enemy's orderly withdrawal, to destroy his nuclear weapon delivery systems, to delay the advance of reserves, to facilitate for friendly forces the rapid passage of enemy defensive lines, crossing of water obstacles, negotiation of difficult areas, etc will also be widely employed in pursuit. It is considered expedient to deliver several assault forces simultaneously or sequentially, as the pursuing tank subunits advance.

It is also pointed out that skillful employment of airborne assaults following nuclear strikes will make it possible more rapidly to exploit pursuit to great

depth and to speed up its pace. When necessary, the efforts of airborne assault forces can be built up by the swift advance of forward units toward these assault forces, followed by attack-echelon tank subunits. In some instances, especially when situation conditions delay forward units and other tank and motorized infantry subunits from reaching assault forces, their efforts can be built up by airlifting motorized infantry subunits. Such an airlift during pursuit can also be employed to reinforce forward units or tanks separated from the remaining forces.

In the opinion of foreign experts, extensive employment of airborne assault forces and airlifting of troops will assume a unique character of parallel pursuit not achieved in the past.

An important role in achieving successful pursuit is also played by continuity. Under present-day conditions each side possesses greater capabilities of quickly taking up defense during withdrawal, of restoring the combat efficiency of defeated troops and even of initiating aggressive offensive actions after delivering nuclear strikes on pursuing troops. It is therefore recommended that withdrawing troops be given no breathing space during pursuit, since only relentless and continuous pursuit demoralizes retreating troops and leads to a more rapid rout of these troops.

It is believed that increasing pressure on the enemy is achieved primarily by employing nuclear weapons, whereby nuclear strikes can also be delivered from depth, and not only directly by the pursuing troops. Also of importance is continuous air support of the pursuing troops. Air will play an especially important role in those cases where the pursuing forces do not possess sufficient nuclear weapons.

It will also be necessary to have support echelons and reserves in order to build up pressure on the enemy during pursuit. This is connected both with an increase in the scope of pursuit, in particular its depth, and the greatly increased fire-delivery and maneuver capabilities of withdrawing ground troops. It is possible, for example, that as a result of massed nuclear strikes delivered by the enemy and employment of other weapons, a part of the pursuing force will sustain heavy casualties, will lose its combat efficiency and require replacement with fresh troops. Some pursuing subunits may be delayed by enemy troops and drawn into protracted fighting, requiring the commitment of fresh forces. There is also the possibility that new axes will open up in the course of pursuit, on which additional forces and weapons must be committed. Support echelons and reserves are also essential for repelling enemy counterattacks and counterthrusts which he may execute during withdrawal following nuclear strikes.

In conditions where a withdrawing enemy force succeeds in holding up pursuing troops, it is recommended that the force of nuclear weapons be employed immediately, as well as airstrikes and artillery fire, with additional forces committed to break the enemy's resistance, with subsequent continuation of pursuit. If there is a possibility of bypassing a blocking enemy force, however, or that zone of physical destruction and contamination in which pursuing troops may be delayed, it is suggested that this possibility be utilized on a preferred basis.

It is noted that with a large spatial scope and high rate of pursuit, it is exceptionally difficult to ensure continuous control of pursuing troops. To remedy

this, it is recommended that the mobility of command posts be increased, including placing them on helicopters. Radio is considered the principal means of control during pursuit; mobile means of communication, especially airplanes and helicopters, can also be extensively employed.

5. River-Crossing Operations

The experience of the past war, as well as combat operations of tank troops in Korea, Vietnam, and during the events in the Near East, indicate that in the course of exploitation it will frequently be necessary for tanks, especially those operating separated from the main forces, to cross large water obstacles on their own.

Two types of river-crossing operation are distinguished: hasty, and deliberate, from a position of close contact with the enemy at the water obstacle. The hasty river-crossing operation is considered the principal mode of crossing water obstacles for tank troops.

Considerable importance is attached to problems of crossing water obstacles in the foreign literature. It is believed that under present-day conditions of conduct of combat operations, water obstacles will be utilized by the adversary primarily as advantageous lines along which he can force advancing troops to deploy and can destroy them during this period with massive employment of nuclear weapons. In order to prevent this, it is recommended that the adversary be crushed at water obstacles just as in the attack, primarily by delivering nuclear missile strikes and by actions by tank subunits without slowing the rate of advance.

It is noted in the foreign press that nuclear weapons can be employed in defeating the enemy at water obstacles for destroying his offensive nuclear weapons, neutralizing and destroying forces on the near bank on approaching the water obstacle, and at strong points and centers of resistance on the far bank, as well as for annihilating reserves brought up to the river from depth.

Following are considered to be the principal conditions ensuring defeat of the enemy at water obstacles and a successful hasty crossing operation by tank subunits: prompt and timely organization of reconnaissance of the enemy and terrain at and near the water obstacle; destruction of enemy offensive nuclear weapons and main forces at the water obstacle; beating the enemy to the punch in seizing important areas, installations and crossing sites at the water obstacle by means of aggressive actions by forward units and airborne assault forces detailed from the tank subunits; prompt and timely movement of river-crossing equipment to the water obstacle and its skilled utilization; rapid crossing of the water obstacle by tanks using all available methods, and exploitation on the far bank without a halt.

As is noted in the foreign press, a hasty river-crossing operation is organized while approaching the water obstacle, calculated to commence a hasty crossing without the slightest delays.* Troops are designated traffic regulating lines, areas

* See K. A. Hansen, "Engineer Support of River-Crossing Operations," KAMPFTRUPPEN, July-August 1972.

for buttoning up and sealing tanks, staging areas for the attack-echelon battalions, as well as for support-echelon units (combined-arms reserves).

Traffic control service is organized: crossing site and crossing area commanders are designated. As is noted in the press, commanders of engineer subunits are designated as crossing site commanders. Commanders of crossing troops are designated by crossing site commanders where tanks are crossing submerged and wading.

Foreign experts believe that successful defeat of an enemy force at a water obstacle and a tank hasty river-crossing operation will be determined primarily by the fire capabilities of the tank troops crossing the river and by the effectiveness of operating reconnaissance. In anticipation of defeating the enemy at a water obstacle, it is recommended that the principal reconnaissance efforts of tank units be directed toward discovering the enemy's offensive missiles, ground troops force and the character of his actions at the water obstacle, the presence of obstacles on the river bottom, and convenient sites for tanks to cross on the river bottom. Reconnaissance of artificial obstacles placed by the enemy on the river bank or bed is one of the most important missions of reconnaissance subunits.

Usually the enemy will prepare the most important water obstacles for defense in advance and will occupy them with reserves moved up from depth and with retreating troops as the attacking forces approach.

It is pointed out in the foreign literature that when turning to the defense at a water obstacle the enemy may have only the minimally requisite forces and weapons directly at the riverbank, with his main forces at depth, primarily tanks, to mount counterattacks with the objective of destroying the advancing side's main forces following delivery of nuclear strikes on the defended bank. Covering forces or withdrawing enemy troops may offer resistance to tank subunits on approaches to a water obstacle. Simultaneously, in order to thwart crossing of the river by tank subunits, the enemy may prepare for and mount strong counterattacks on the near bank, into one or both flanks of the troops advancing to the river.

Foreign experts believe that under such conditions nuclear missile weapons should inflict sufficient casualties and damage on the major enemy forces on the near and far banks while the advancing tanks are approaching the river, ensuring unhindered approach to the water obstacle, a hasty crossing and rapid mopping up of the enemy's main forces on the far bank. Nuclear weapon requirements for hitting an enemy force at a water obstacle will be determined by the concrete composition of the force and the nature of the enemy's actions.

In order to complete defeat of counterattacking enemy troops operating on the near bank, it is recommended that one assign the minimum number of tanks capable of completing the rout of these enemy troops with aggressive actions in the shortest possible time following nuclear strikes, and capable of eliminating the threat to the flanks of the advancing tank subunits.

The main tank forces, operating out of contact, should advance swiftly toward the river, knocking back the enemy's covering forces with strong forward units equipped with self-propelled river-crossing equipment. It is recommended that tanks approach the river on a broad frontage, along separate, disconnected axes, moving

the river-crossing equipment up behind the forward units. When attack-echelon tank subunits reach the river, repeated strikes by nuclear and conventional weapons may be delivered on newly discovered offensive nuclear weapons and enemy troops on the far bank, after which the tanks, which have reached the river, will cross it without a halt, by ferry, bridge, assault crossings and crossing on the river bed, and will advance swiftly on their axes to depth in an exploitation phase, mopping up enemy forces remaining on the flank and in the rear with attacks by support echelons and reserves.

In view of the considerable vulnerability of crossing equipment (bridging equipment and self-propelled ferries) to enemy nuclear weapons and air, tank subunits will cross under their own power by fording, while artillery and motor transport equipment will cross on board amphibious carriers. Figure 6.5.4 shows tanks crossing submerged under their own power, and Figure 6.5.5 -- artillery and motor transport crossing on self-propelled amphibious equipment.

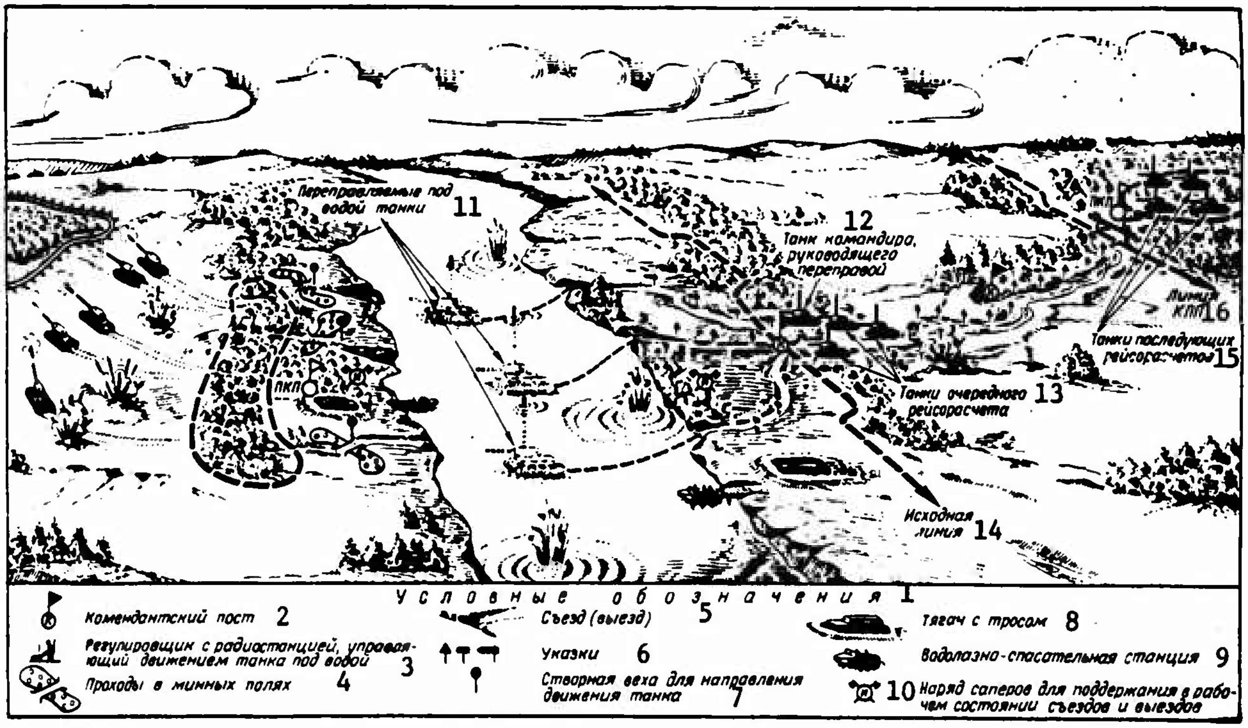


Figure 6.5.4. Tank Subunit Crossing River Under Its Own Power Submerged (variant)

Key:

1. Legend
2. Crossing area command post
3. Traffic controller with radio set, controlling tank movement submerged
4. Lanes through minefields
5. Water entry (exit)
6. Markers
7. Marker stake for guiding a tank
8. Prime mover with cable
9. Diver-rescue station
10. Combat engineer detail for maintaining entry and exit ramps in working order
11. Tanks crossing under water
12. Tank of commander supervising crossing

(Key to Figure 6.5.4, cont'd from preceding page)

13. Tanks of following wave
14. Line of departure
15. Tanks of subsequent waves
16. Traffic regulating line

ПКП. Traffic post

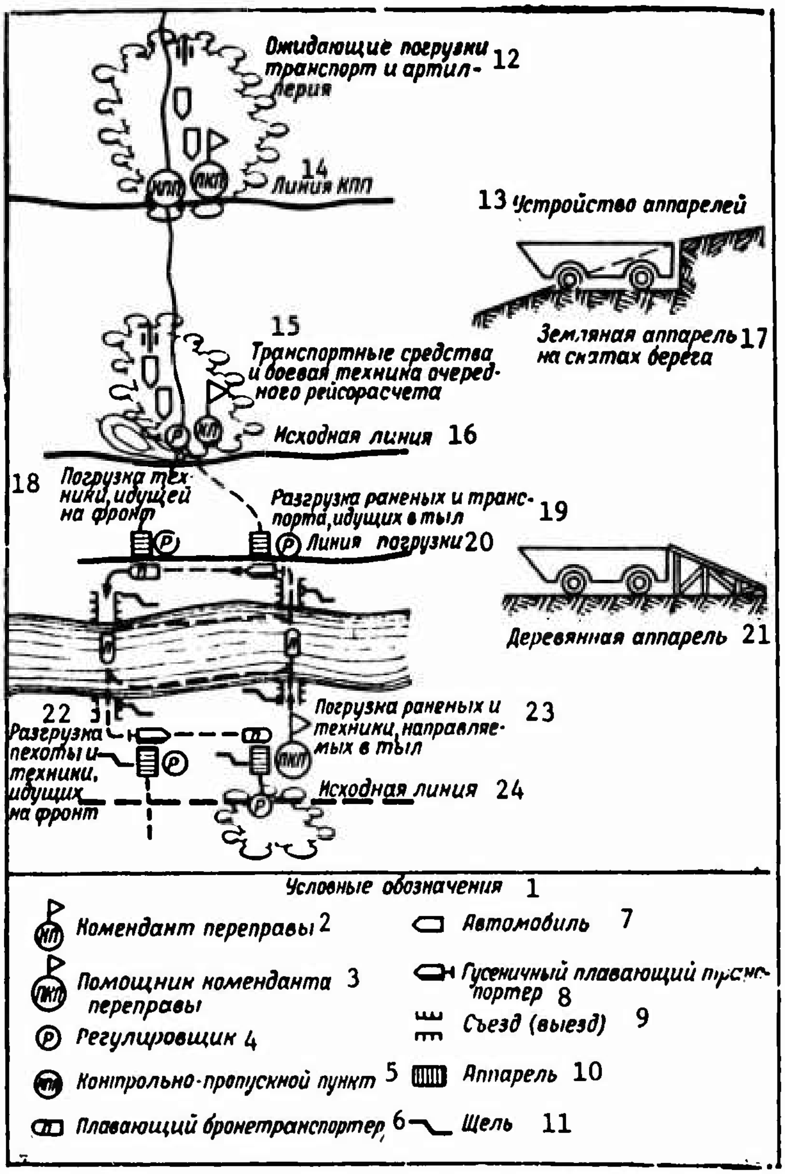


Figure 6.5.5. Artillery and Motor Transport Crossing on Self-Propelled Crossing Equipment

Key:

1. Legend
2. Crossing area commander
3. Assistant crossing area commander
4. Traffic controller

(Key to Figure 6.5.5 on preceding page, cont'd)

5. Traffic post
6. Amphibious armored personnel carrier
7. Truck
8. Tracked amphibious carrier
9. Entry (exit)
10. Ramp
11. Slit trench
12. Vehicles and artillery awaiting loading
13. Ramp arrangement
14. Traffic regulating line
15. Transport vehicles and combat equipment of next wave
16. Line of departure
17. Earth ramp on sloping riverbank
18. Loading of equipment moving to the battlefront
19. Off-loading of wounded and transport vehicles proceeding to the rear
20. Loading line
21. Wooden ramp
22. Unloading of infantry and equipment proceeding to battlefront
23. Loading of wounded and equipment proceeding to the rear
24. Line of departure

In the course of exploitation, as a result of swift tank actions, in many cases the enemy may not be able promptly to move his reserves up to the water obstacle to take up a defensive position, and they may reach the river simultaneously with the advancing tanks and motorized infantry. In order to create more favorable conditions for his reserves and to engage them at the river, the enemy will seek to slow the pace of the advancing troops toward the river, offering resistance with retreating troops.

In such a situation it is recommended that enemy offensive nuclear weapons discovered by reconnaissance be destroyed while advancing toward the river, with maximum casualties inflicted on the enemy's approaching reserves, in order to thwart their organized advance to the river and to diminish their combat efficiency to a significant degree.

It is noted abroad that under these conditions tank subunits should swiftly approach the river on their axes, operating principally in columns and deploying only a part of their forces in order quickly to crush the retreating enemy who is offering resistance.

When attack-echelon subunits reach the river, enemy missiles and troops which have succeeded in reaching the far bank and are capable of offering resistance, should be destroyed by fire from all weapons of the advancing subunits. Forward units and main forces cross the river without a halt, employing all available crossing equipment and all possible crossing methods.

As they cross to the far bank, attack-echelon tank subunits exploit swiftly to depth and mop up surviving enemy ground troops and nuclear missile weapons.

As is indicated in the foreign press, sometimes the situation may develop in the course of exploitation that the enemy will offer substantial resistance on the near bank. He may deliver a strike on troops reaching the river by missile units, simultaneously moved across the river, and air, and he may create a radioactive contamination zone directly ahead of the river, in order to gain time to withdraw his troops behind the river and to move reserves up from depth.

In this case it is recommended that measures be taken to destroy as rapidly as possible enemy missile and ground forces located beyond the radioactive contamination zone and on the far bank, that the zone be crossed on routes with the lowest radiation levels, that a hasty river crossing be executed on a broad frontage and, commencing exploitation, that efforts be rapidly shifted to depth in order to crush approaching enemy reserves.

Thus, according to the views of foreign military experts, in all cases tank subunits should execute hasty river-crossing operations, without delay, without massing troops on the near bank, and without decreasing the overall tempo of advance. It is recommended that water obstacles be crossed simultaneously by as many tanks as possible, with utilization of all possible crossing equipment and methods, on a broad frontage, and after inflicting maximum damage on the enemy with all available weapons. Tank offensive action on the far bank should consist in swift advance to depth without any delays on the bridgeheads.

6. Tank Actions in Radioactive Contamination Zones and Areas of Heavy Destruction

In various foreign publications military experts, discussing the casualty-producing elements of a nuclear burst, point out that employment of nuclear weapons on the battlefield by both sides will lead to the formation of numerous radioactive contamination zones and areas of heavy destruction, which tanks, during the exploitation phase, will be compelled to bypass, cross, or fight in these zones. In addition, the enemy may deliberately establish zones with levels of radioactive contamination and heavy physical destruction in the path of the main battle groups of the advancing forces, which will be tank troops. It is believed that the objective of establishing such zones can be the following:

to inflict damage on tanks operating out of contact, to delay their further advance, and to gain time to concentrate friendly reserves in their path;

establishment of conditions for repeated nuclear weapon strikes on penetrating troops as they are crossing a zone;

pinning down tank subunits in order to attack with friendly reserves in a sector guaranteeing maximum success;

securement of requisite conditions for deployment and attack by friendly troops.

The character of established zones and areas will depend to a significant degree on objectives. In many instances they will amount to several tens of kilometers in frontage and depth and will cover the entire zone of advance of the attacking forces.

During the conduct of combat operations in zones of heavy radioactive contamination, personnel of subunits, including tank subunits, may receive a substantial one-time radiation dose and become incapacitated for all practical purposes. Therefore the methods and character of actions of tanks and tank subunits when fighting in contamination zones should be directed toward performing the assigned missions with determined, highly mobile and swift actions and at exiting from the contaminated zone as quickly as possible and with minimal radiation doses.

It is noted in the foreign press that radioactive contamination zones are crossed figuring personnel receiving the least radiation doses and maintaining (upon exiting from the zone) combat efficiency for fighting a powerful and aggressive adversary.

Modes of crossing radioactive contamination zones and areas of heavy damage will be determined first and foremost by the tactical and meteorological situation, radiation levels, degree and nature of physical destruction on selected routes, the presence of areas of fires, blowdown, as well as the nature of hostile activities in and immediately beyond the zone.

It is pointed out that, depending on these factors, tanks can cross a radioactive contamination zone without a halt, without waiting for radiation levels to drop, detouring areas with high radiation levels, after high radiation levels drop off, or with an intelligent combination of the above enumerated methods.

When crossing radioactive contamination zones without a halt, it is recommended that tanks lead the columns, followed by motorized infantry subunits on armored personnel carriers, followed by the remaining troops. Zones will be crossed following routes and axes with the lowest radiation level, while troops will proceed at elevated speeds with increased gaps between vehicles and subunits, employing individual protective gear.

Bypass routes are selected on the basis of reliable and complete information on radiation levels in areas and on axes, obtained from all types of reconnaissance and radiation situation forecasting.

It is believed that if it is impossible to cross zones without a halt as a consequence of extremely high radiation levels and lack of information enabling one to select routes with the lowest radiation levels, tanks and tank subunits can cross the zone after radiation levels have dropped off. In this case troops are dispersed forward of the zone into assembly areas and provided reliable protection against air attack. Tank subunits employ this method, however, only in exceptional cases, since it results in a slower rate of advance.

If it is impossible to cross a zone without a halt or if the entire force cannot bypass it simultaneously, tank subunits will cross it in a combined manner, that is, that part of the forces required to execute the mission can swiftly cross the zone on tanks without a halt, while other troops can be airlifted, and the remaining troops can cross the zone after radiation levels have dropped off or can bypass heavily contaminated areas following reconnaissance of suitable routes and axes.

Foreign military experts believe that in all cases methods used by tanks to cross radioactive contamination zones and areas of heavy destruction should be selected in conformity with the concrete situation, should be crossed only in cases of extreme necessity and only by those troops which were located in the zone or directly forward of the zone.

7. Features of Tank Operations in Conditions of Mountain-Desert and Desert-Steppe Terrain

Under present-day conditions, in some theaters of military operations it will be necessary in the course of an offensive to cross flatland desert-steppe and rugged

mountain areas with various soil (sand dunes, salt flats, granite-rocky ground) and climatic conditions. Combat operations will be influenced by the absence of population, limited number and poor quality of roads, lack of local building materials, food resources and water.

Diversified and complex terrain conditions can variously affect the mobility and pace of action of tanks. In desert-steppe terrain, for example, where broad dispersion and free deployment of troops are everywhere possible, and extensive maneuver off roads in many instances, and where defensive lines may be tens and even hundreds of kilometers distant from one another, the most favorable conditions are created for maneuver and conduct of swift offensive operations.

In mountain areas, for example, with their rugged topography, as well as in areas of sand dunes, the pace of advance may prove to be even slower than that planned under normal conditions.

In view of the great diversity of topography and especially the nature of the enemy defense, combat operations under these conditions will also be distinguished by considerable variety.

In mountain-desert regions, where areas and lines which are advantageous for defense are especially abundant, and maneuver capabilities are extremely restricted, in order to defeat and destroy the enemy it will frequently be necessary to execute attack with penetration of defensive lines.

Foreign military experts believe that one of the most important conditions for successful accomplishment of missions pertaining to defeating large enemy forces in mountains and on deserts is advance by tanks into the rear and onto the principal lines of communication of the defending enemy with the objective of capturing principal sources of water supply, rear area supply depots, supply routes and important road junctions. The role of forward units, airborne assault forces and raiding parties increases significantly in connection with this. It is noted in the foreign press that when conducting an offensive operation it is essential to bear in mind that usually the enemy will establish the strongest and most aggressive defense, as well as the greatest densities of men and weapons on avenues of approach to the most important objectives, along main roads and the most accessible axes. Frequently there can be no continuous defensive front.

It is believed that in mountainous regions there will be more extensive employment of a combination of actions by main forces to achieve frontal penetration of defensive lines, with a deep turning movement to envelop the enemy with part of one's forces across less accessible terrain, in order to attack the enemy in the rear or to capture important objectives in the enemy's rear area.

The main attack in mountainous terrain is mounted along roads, trails, and valleys, in combination with actions by separate motorized infantry or jaeger subunits. It is believed that more time than normal will be required to establish the requisite force grouping and to prepare for troop actions. It will be especially difficult to concentrate and position the requisite quantity of artillery on the main axis of advance in a prompt and timely manner. Therefore destruction and suppression of the enemy prior to commencement of an attack will frequently be assigned chiefly to air and artillery.

It is noted in the foreign press that the natural conditions of mountain-desert and desert-steppe terrain should also be taken into consideration when selecting the time of initiation of an offensive operation. Movement from concentration areas across sandy soil during daylight hours will lead to the creation of a very thick, tall cloud of dust above the path of movement of tank subunits, which will be visible at a distance of many tens of kilometers and will enable the enemy to determine the direction of tank movement. Therefore in order to achieve the element of surprise, it is advisable to initiate an offensive operation at dawn or in the afternoon.

It is believed that in order to achieve greater concealment in employment of tanks it is essential to utilize terrain conditions favoring movement and the possibility of extensive dispersion and rapid execution of redeployments and movements in a short period of time and covering considerable distances. On deserts and steppes tank subunits can be positioned at a considerable distance from one another both laterally and in depth, and over an area considerably exceeding the size of dispersal areas designated under normal conditions. In mountains, possibilities of dispersing tanks laterally are extremely limited, and therefore they will for the most part be dispositioned in depth.

Foreign military experts believe that in principle combat formations of subunits will include the same elements as in normal conditions, but the composition and positioning of certain elements will contain some peculiarities. In all cases strong reserves will be needed, capable of carrying out suddenly arising missions under difficult terrain conditions.

For execution of turning movements across difficult terrain, it is recommended that the order of battle include subunits specially trained for such activities. When breaches and weak points form in the enemy's defense, it is advisable to have strong combat detachments reinforced by engineer subunits forward of the tank subunits.

It is claimed that in this case engineer subunits should quickly lay out cross-country routes and negotiate obstacles under various soil conditions -- salt flats, dunes and soft sand, rock, and with heavy radioactive contamination of terrain. In order to increase the rate of advance, especially wheeled transport vehicles, in loose-sand areas movement support subunits must contain mechanized equipment for laying wheel treadways, permitting passage of transport vehicles and tanks at maximum possible speed. It is noted abroad that when determining the order of battle of troops in mountains it will be necessary, to a greater extent than under normal conditions, to consider such factors as troops being tied close to roads, considerable depth of columns and the entire order of battle as a consequence of increased gaps, the need to disperse means of reinforcement in order to increase the independence of subunits moving in columns and on separated axes, and increased time for deploying from march columns to combat formations.

On the vast open spaces of deserts and steppes, particular importance is assumed by precise coordination between tanks and air, and in mountains -- with airborne assault forces; the importance of forward units is also increased.

Forward units and combat detachments in mountains will consist chiefly of motorized infantry or mountain troops subunits, reinforced by tanks. Helilifting of combat detachments may be extensively employed in mountains.

It is believed that in the course of exploitation, tanks will frequently have the task of penetrating a hastily occupied enemy defense. The enemy will have considerable opportunities for rapid establishment of such a defense during actions in mountain regions. Penetration of a hastily occupied defense, depending on terrain conditions, may require the employment of various methods of tank actions. In desert-steppe terrain, it will be most advantageous to bypass the defending enemy in order to attack from the flank or rear. If a turning movement is impossible or disadvantageous, it is advisable to penetrate the enemy defense simultaneously on several axes. Assaulting the enemy by tanks without a halt in attack position, immediately following preliminary bombardment, and advance at a rapid pace, in conformity with the technical capabilities of the tanks under given terrain conditions, will make it easier to crush the defending forces and enemy reserves and will make it possible to thwart hostile measures to offer opposition to troops attacking deep in the defenses.

It is claimed that when penetrating a hastily assumed defense in mountain-desert terrain, as well as in desert and steppe regions, one should proceed from the concrete conditions and recommendations given for offensive operations in mountains and on flatland terrain, supporting the assault with artillery fire and airstrikes. Airborne assault forces are delivered to attack the enemy from the rear on the axes of tank advance.

Successful employment of tanks in mountain and desert-steppe regions involves the necessity of reinforcing them to a substantially greater extent than under normal conditions with engineer subunits capable of supporting tank operations in difficult soil conditions.

Foreign experts note that one important task for successful troop operations will be skillful troop control on the part of commanders of all echelons. Therefore in organizing control it will be necessary to provide more frequent and more thorough briefing of commanders and assignment of more general missions. Independence and initiative of commanders of all echelons assume particular importance.

8. Trends in Development of Methods of Conduct of Offensive Operations by Tanks

The land still remains man's natural element, and the final outcome of an armed conflict will depend on ground forces, and particularly tanks and the methods of action employed by them. The newer the mode of action and the greater the element of surprise, the greater the effect achieved on the battlefield.

Proceeding from this, foreign military experts believe that selection of modes of attack should be based on the principle of achievement of the element of surprise. It follows from this that under conditions of extensive employment of nuclear weapons, tank subunits require new modes of concentration on the battlefield, deployment and engagement, establishment of battle groups for penetrating the defense and crushing reserves without a halt in attack position, continuous exploitation to considerable depth at a high rate of advance, and maintenance of

continuous combat efficiency. Mobility and armor protection will be of decisive significance for gaining the element of surprise and seizing the initiative.

It is believed that in the future, when advancing toward the enemy's defense, troops should proceed in dispersed formations and should swiftly concentrate to mount an assault on the selected axis. In order to avoid nuclear strikes, they should not break contact with the withdrawing enemy, and after completing the assigned mission they should immediately disperse in order to avoid taking effective fire.

It is believed that tank troops can attack in columns, delivering fire while moving from tanks, infantry combat vehicles and armored personnel carriers; particular attention should be devoted to engaging hostile antitank weapons and aircraft.

For combatting antitank weapons and tanks, it is recommended that tactical air be employed, as well as air defense troops (for destroying enemy fixed-wing and rotary-wing aircraft armed with antitank missiles), missile troops and artillery, tanks and motorized infantry subunits, and electronic countermeasures gear.

It is noted in the foreign press that ɔmbat against enemy antitank weapons will be organized in zones: main zone, on the flanks, and in the zone of maneuver of enemy antitank weapons and tanks. It is recommended that all weapons be employed against hostile antitank weapons and tanks in these zones. Preference is given to two weapon systems, however: rocket artillery and helicopter gunships armed with ATGM. One rocket artillery brigade consisting of two rocket launcher battalions (54 launchers), for example, is capable of delivering 24 tons of antitank mines, covering an area of approximately 120 km^2, a distance of 60 km within five minutes. It is emphasized that 1.6 tons of antitank mines (filling the warheads of eight rockets) are capable of destroying approximately 50 percent of a tank battalion dispositioned in an area of 4 km^2 and totaling 44 tanks.*

The foreign press considers as one promising mode of conduct of an offensive operation the air offensive, whereby main battle tanks advance swiftly in columns, while motorized infantry and light tanks are sequentially airlifted with the aid of army aviation. Tanks should operate in close coordination with assault combined units, tactical and operational assault forces. In coastal areas the air offensive system may also include tank amphibious landings. Therefore operational and tactical airborne assault forces as well as assault combined units and units will engage enemy tank forces and destroy the enemy's nuclear missile and antitank weapons.

Adoption by the armies of capitalist countries of heavy helicopters and fixed-wing aircraft capable of airlifting main battle tanks will increase to an even greater extent the significance of the air offensive. Consequently, with this offensive method, coordinated action should be particularly thoroughly worked out between tanks advancing on the ground, airborne assaults, assault combined units, air, missile and artillery units, as well as engineer troops, tactical and army rear services.

It is reported in foreign periodicals that tank amphibious assaults will be extensively employed in the conduct of an offensive in coastal areas as well as in

* See WEHR UND WIRTSCHAFT, July-August 1972.

negotiating tidal zones. It is pointed out that tank subunits and units will cross water expanses with their own resources, with the aid of flotation equipment and amphibious vehicles. Employment of nuclear weapons, as well as the high mobility of ground troops and their relative independence will dictate the absence of a continuous front and the conduct of combat actions by axes, with formation of individual focal areas of combat, interacting in time and space.

Chapter 6. DEFENSE

1. Employment of Tanks in the Defense

In conditions where attack is impossible or inexpedient, troops shift to the defense, as we know.

Defensive operations aim primarily at repelling the attack of superior enemy forces, of covering or holding occupied positions. Defense makes it possible to save manpower and weapons, to gain time to bring up reserves or to redeploy, and to create favorable conditions for passing to the offensive. In the opinion of foreign experts, in the conduct of defensivee operations with employment of conventional weapons, the objective of defense is achieved by means of stubbornly holding ground in combination with aggressive counterattacks, and under conditions of employment of nuclear weapons -- chiefly by inflicting maximum casualties on the attacking enemy and destroying his battle groups with nuclear strikes and counterattacks.

Tank subunits can shift to the defense both during withdrawal and advance. Depending on the situation, they can shift to the defense out of contact with the enemy, that is, in advance, or in conditions of contact.

In connection with the great striking power of tanks, they are naturally designed more for offensive actions. As the experience of the last war indicated, however, the situation may develop so that on a number of axes tank subunits and units may also shift to the defense at certain times.

Shift to the defense always has been and most frequently will continue to be a temporary phenomenon for tank troops. On the scale of tank armies and corps, for example, defense in the past war was organized chiefly for the purpose of repelling counterthrusts by large enemy tank forces, for holding an outer or inner perimeter of envelopment, as well as important operational positions and bridgeheads. As a rule the necessity to shift to the defense was dictated by a substantial enemy superiority in men and weapons, particularly tanks and aircraft. For example, in the operations of the First Ukrainian Front in 1943, the Second Ukrainian Front in February 1944, and the First Belorussian Front in August 1944, tank armies contained 80-160 tanks and self-propelled guns, while the German-fascist command concentrated 4-5 tank divisions containing from 100 to 600 tanks in the counterthrusting enemy forces operating in the zones of these fronts.*

* See A. I. Radziyevskiy, "Tankovyy udar" [Tank Attack], Moscow, Voyenizdat, 1977, page 187.

As a consequence of the fact that during the war years tank armies (corps) spearheaded attacking forces, as a rule counterthrusts by large enemy forces would be aimed at them.

During the war years tank brigades (regiments) and battalions would usually shift to the defense in the course of an offensive or as a result of an unsuccessful outcome of a meeting engagement. They would be positioned both in the forward and support echelon and, depending on their position in the order of battle, would usually shift to the defense in conditions of close contact with the enemy, but sometimes they would also organize defense out of contact. Foreign military experts believe that under present-day conditions tank subunits and units may be positioned in various elements of troop combat formations when shifting to the defense: in the forward and support echelon, or in the combined-arms reserve. The task consists in ensuring the fullest and most effective utilization of tank performance characteristics and capabilities in any disposition of tank subunits and units.

It is believed that in the defense it is advisable to utilize tanks primarily for mounting counterattacks. For this purpose the majority are positioned as a rule at depth, in support echelons and combined-arms reserves.

During the Great Patriotic War, in the defense of rifle divisions and corps, attached tanks were positioned practically always in the support echelon or reserve and were employed only for counterattacks. Only in certain instances was a small portion of tanks utilized for reinforcing the antitank defense of forward-echelon rifle subunits and units. In these cases tanks were positioned at antitank strong points or in ambushes. Most frequently they would be utilized on the most important axes, where it was necessary to establish an exceptionally strong defense from an antitank standpoint. In the defense at Kursk in July 1943, for example, as many as 10 tanks were sometimes included in the antitank strong points of rifle battalions.

In mechanized brigades and corps, tank battalions were frequently positioned in the forward echelon, especially when it was necessary to establish a solid defense in a short time. In the Korsun'-Shevchenkovskiy Operation in February 1944, for example, the 233d Tank Brigade of the V Mechanized Corps was assigned the mission of taking up defense on the outer perimeter of envelopment. It was expected that the enemy would undertake intense efforts to break through to the encircled force and to relieve it.

In that same operation, the 6th Tank Army was also positioned in the forward echelon of the defending forces, which provided a density of weapons against enemy tanks of up to 18.1 units per kilometer of frontage.

In the latter half of the past war tank units and combined units began shifting to the defense more frequently in forward echelons as well. This was due to the fact that since the Soviet Army troops had shifted to decisive offensive operations, tank units and combined units proceeded to advance to depth and, on encountering large enemy forces, found themselves in the forward echelon when shifting to the defense. In addition, under conditions of high mobility actions, tank units and combined units, as the most mobile, were able more rapidly to advance to favorable positions for defense and to organize defense at these positions in the shortest period of time.

Beginning with the battle of Kursk, in the course of the war there were many examples of employment of tank units and combined units for holding defensive lines. And although frequently such employment of tanks in the defense was not planned in advance, for all practical purposes it was accomplished fairly frequently. Tank brigades and corps operated in the defense independently or together with rifle units and combined units. In July 1943, for example, the 200th Tank Brigade was reinforced with rifle subunits and set up a defense with a motorized rifle and a tank battalion in the forward echelon, reinforced by rifle subunits. A tank battalion with a motorized rifle battalion was in reserve. As experience showed, combining tank and rifle subunits facilitated maintaining mutual support and increased stability of the defense.

When repelling counterattacks and counterthrusts by large enemy forces, as well as with an unsuccessful outcome of a meeting engagement or encounter battle, tank units, combined units and armies would shift to the defense independently and would sometimes conduct it separated from other forces. Such were the actions of the 1st Tank Army at Bogodukhov in August 1943 in the Belgorod-Khar'kov Operation, the 3d Guards Tank Army south of Fastov in November 1943 in the Kiev Operation, the 6th Tank Army in February 1944 in the Korsun'-Shevchenkovskiy Operation, the 2d Tank Army in August 1944 in the Lublin-Brest Operation, the 3d Guards Tank Army in August 1944 in the Ľvov-Sandomierz Operation, and the 5th Guards Tank Army in January 1945 in the East Prussian Operation.

The role of tanks in the defense of units and combined units containing tank subunits is determined by the fact that, possessing strong armor protection, they make the defense resistant to nuclear attacks and airstrikes, while the defense becomes more aggressive and mobile thanks to their high mobility. In the past war, for example, the presence of tanks in such units and combined units made it possible simultaneously to establish a solid antitank defense in forward-echelon subunits and units and to maintain a strong armor reserve (strike force) to crush enemy forces which have penetrated the defense.

During the independent defense of important positions, the great firepower of tanks and their armor protection ensured reliable repelling of a massed assault by tanks and infantry ahead of the forward edge of the battle area, delivery of effective fire from weapon positions (in coordination with mobile obstacle detachments and antitank reserves), as well as repelling of assaults by the advancing enemy at positions or lines prepared deep in the defense, and defeat of this adversary with powerful counterattacks (counterthrusts). The high maneuverability of tanks in combination with great striking power made it possible also to assign them the mission of destroying landing airborne assault forces.

In a number of instances defending force tanks employed in the support echelon (reserve) would be utilized to close breaches or for rapid replacement of troops from the forward echelon which had lost combat efficiency. The strong armor protection and mobility of tanks enable them to create in the shortest possible time a solid screen in the path of advancing enemy tanks even on unprepared terrain and directly in areas of employment of nuclear weapons.

In the final analysis skilled employment of tanks in the defense makes it stable, capable of withstanding attacks by superior enemy forces from any direction, and

creates good preconditions not only for retaining occupied positions and repelling enemy assaults but also for preparing conditions to shift to a decisive offensive.

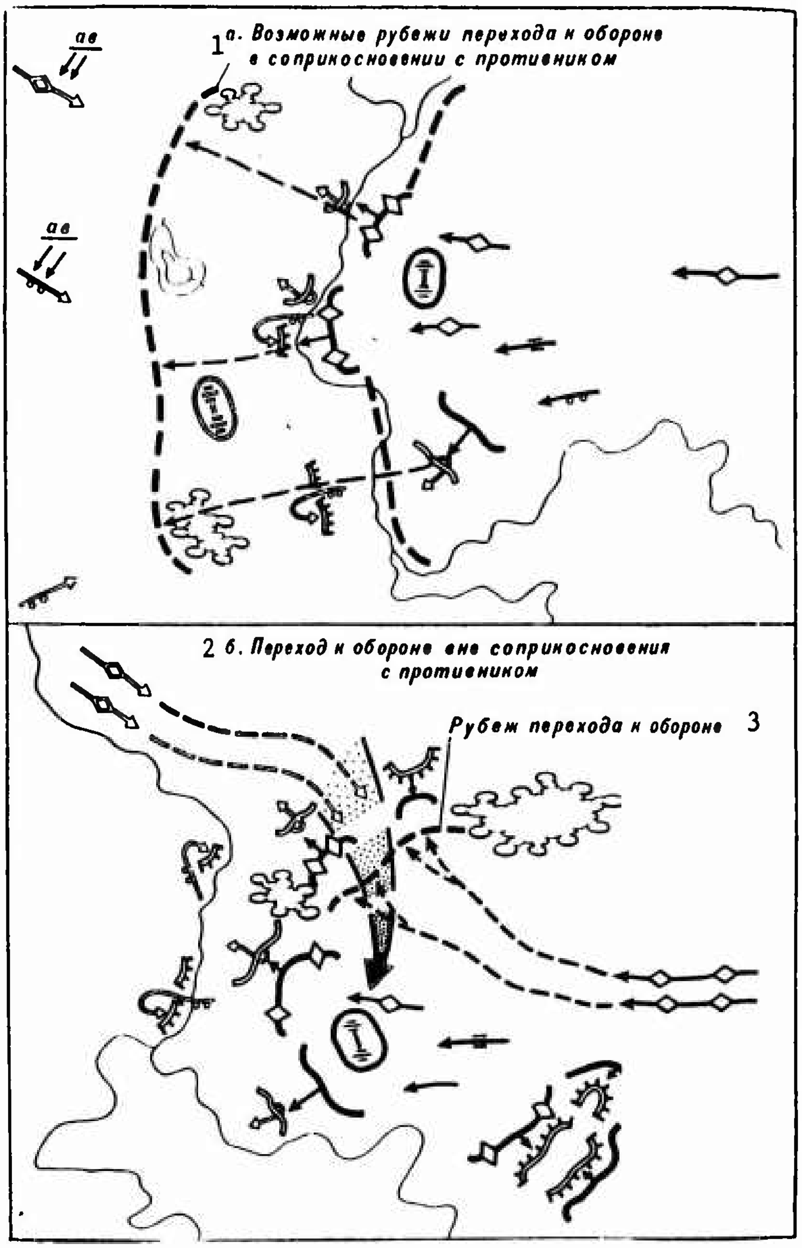


Figure 6.6.1. Conditions of Shifting of Tanks to the Defense

Key:

1. Possible lines of shift to the defense in contact with the enemy
2. Shift to the defense out of contact with the enemy
3. Line of shift to the defense

2. Conditions of Shifting of Tanks to the Defense

Successful employment of tanks in the defense depends in large measure on the situation conditions in which tank units and subunits will shift to defensive actions. Advancing in the attack echelon, tank units when shifting to the defense will most frequently take up the defense in close contact with the enemy (Figure 6.6.1).

Depending on the nature of combat actions, the situation for organizing defense by tank units and subunits will vary. The experience of the Great Patriotic War, for example, indicated that tank corps and armies shifted to the defense most frequently in the final stages of offensive operations.

Limited time to organize defense, taking up defense in close contact with the enemy, with aggressive enemy actions, and conduct of defense frequently with troops considerably below strength, separated from other forces and with exposed flanks are typical situation conditions during shifting of tank units and subunits to the defense in connection with high-mobility actions by the opposing sides and the decisiveness of pursued objectives.

In connection with limited time for organizing defense, the ability to make decisions and to assign or communicate missions in the shortest period of time is required of commanders of all echelons and staffs. In the past war, for example, sometimes there were only a few hours, and occasionally less than one hour at the disposal of a subunit or unit commander to allocate missions.

Shifting to the defense in contact with the enemy was characterized by the fact that subunits (units) had to establish a combat formation, dig in tanks and other weapons, and set up a fire plan in a situation where the enemy could quite aggressively hinder deliberate performance of activities of establishing a defense, and sometimes could greatly impede such activities. In the past war tank brigades and corps which shifted to the defense in separation from other forces would usually set up an all-round defense.

Thus the conditions of shifting of tank subunits and units to the defense are distinguished by a high degree of complexity and intensity. As a consequence of the specific character of these conditions, a number of specific demands are imposed on organization of defense.

For example, the threat of employment of nuclear weapons demands of troops in the defense a high degree of resistance to the effects of these weapons; mass employment of tanks requires that defense be organized primarily as an antitank defense, while the threat of aggressive enemy air action requires organization of antiaircraft defense.

Sometimes when shifting to defense tank units and subunits may be under strength, which will require that they be appropriately brought up to strength.

Sometimes tank units and subunits may shift to the defense out of contact with the enemy. In these cases it may be established stronger from an engineer standpoint, and favorable terrain conditions will be more fully utilized.

3. Organization of Defense of Tank Troops

Shift to the defense in close contact with the enemy is a complex process. This is due to the fact that the commander and his staff must, simultaneously with execution of measures pertaining to organizing defense, also direct troop actions to defeat in detail the opposing enemy force. Depending on where the defensive line indicated by the higher commander is located -- forward of the area occupied by the troops or to the rear -- the content of matters pertaining to controlling the actions of subordinate forces and weapons differs. During the Great Patriotic War, for example, when orders were received to defend a line located forward, destruction of the opposing enemy force, advance to that line and consolidation on it would be organized. The requisite redispositioning of forces and weapons would be performed while advancing to the designated line. Subunits and units (combined units) would move forward to the defensive line in such a manner as to end up in the area or zone where they were to organize a defense.

If a defensive line was indicated in the area occupied by troops, first of all they would organize its consolidation, followed by seizure of terrain onto which friendly forces and weapons had not yet advanced.

If a defensive line was assigned in the rear of friendly forces, part of the forces would dig in at the present position, while the main forces would be moved back, under their cover, to the indicated defensive line in the rear.

When making a decision to defend, a commander would usually determine the general plan of action, the content of missions assigned to subordinate subunits and units, and would specify the procedure of mutual support and control.

The general plan of action provided for maximum effective employment of available forces and weapons, ensuring delivery of maximum fire on the enemy on the avenues of approach to the defense and forward of the main line of resistance, as well as defeat in detail of enemy forces penetrating the defense. In order to achieve this objective, the general plan of action would specify the sequence of hitting the enemy with air and artillery at maximum expedient ranges forward of the defensive line, by tanks, antitank and other weapons by direct fire, immediately as the enemy initiated the assault; areas firm retention of which determines stability of the defense; procedure and sequence of delivering fire on penetrating enemy forces and directions of execution of counterattacks; order of battle and layout of the defended area (defensive zone).

According to the experience of the war, in order to inflict on the advancing enemy the most effective fires, points, lines or areas would be designated on avenues of approach to the defense, at which the greatest damage would be inflicted on the enemy, where his movement could be restricted and where he could be contained. For example, artillery and airstrikes on the enemy would be scheduled for when he was crossing water obstacles, passes, defiles, forest and other difficult terrain. Artillery fire would be scheduled on the far avenues of approach, for those areas and lines where maximum massing of enemy forces and weapons was anticipated, especially on deployment lines.

Heavy delivery of effective fire would be scheduled so as to increase volume as the enemy approached the defense. For this purpose, repeated strikes and delivery of artillery fire on the enemy would be specified at lines of initiation of the assault, ahead of obstacles, in gaps in the formations of forward-echelon subunits and units, as well as deep in their dispositions.

One of the most important questions examined in the general plan of action is dispositioning of forces and weapons for defense, that is, arrangement of the order of battle.* When setting up the combat formation, there should be ensured effective employment of all weapons to deliver effective fire on the enemy on the avenues of approach to the forward edge of the battle area, on the FEBA, and at depth, with tanks able to utilize their performance characteristics to the greatest degree. The layout of the defensive combat formation should also ensure capability to execute swift maneuver by forces and weapons to threatened sectors.

In connection with the fact that in the course of a unit attack subunits usually are in a specific formation, when setting up a force grouping (when shifting to the defense), one should consider existing capabilities for their necessary redisposition in conformity with the concretely developing situation.

In the past war available forces and weapons would be dispositioned in depth when setting up the order of battle. On the one hand this made it possible to build up the force of resistance and delivery of fire on the enemy in case of penetration of the defense, while on the other hand it made it possible to execute maneuver by forces and weapons for mounting counterattacks (counterthrusts), closing breaches in the defense, and replacing forward-echelon subunits and units when they lose their combat efficiency.

Tank units and subunits in the defense would be dispositioned in one or two echelons. If the situation was insufficiently clear, and if in addition there was a threat of delivery of enemy attacks not only frontally but from the flanks as well, a strong combined-arms reserve would be established in addition to or in place of the support echelon. A single-echelon arrangement would be employed in the absence of adequate forces and with the necessity of establishing especially high densities of forces and weapons in the occupied position in order to hold it in firm possession.

Depending on the anticipated nature of enemy actions and the designated general plan of action for friendly troops, the composition of echelons is quite varied. The forward echelon is not always set up with considerably more forces and weapons than the support echelon or reserve. In the armies of the United States and the FRG, for example, the role and composition of the echelons of a defending division are dictated chiefly by the type of defense. In the conduct of a mobile defense, the bulk of forces and weapons are assigned to brigade and division support echelons (reserves). The forward echelon consists primarily of motorized infantry subunits (units). It is believed that the presence of a large number of tanks in the support echelon will enable the defense to be made most aggressive.

* D. A. Ivanov et al, "Osnovy upravleniya voyskami" [Fundamentals of Troops Control], page 241.

During the Great Patriotic War tank brigades frequently would set up a solid defense in rapid fashion and would inflict heavy casualties on the enemy with aggressive actions. In the fighting southwest of Mtsensk, for example, the 4th Tank Brigade was assigned the mission of setting up a defense during the night of 4 October 1941 on the Orel-Mtsensk highway and providing cover for concentration of the I Special Corps in Mtsensk.

The brigade shifted to the defense in separation from other forces, with exposed flanks. Under these conditions, in view of the threat of turning movements around the flanks of the defensive line, emphasis in the defense was placed on aggressive conduct with utilization of favorable conditions of the terrain, which abounded in ravines and strips of woodland. The brigade was dispositioned in depth in order to ensure increase in force of resistance, execution of maneuver and counterattacks -- up to half of the brigade's forces were placed in the support echelon and reserve. A substantial percentage of the tanks were employed in ambushes and at depth. It was precisely this which enabled the brigade successfully to accomplish its assigned mission.

In the past war tank armies were usually of a single-echelon formation. As a rule they would shift to the defense at the concluding stage of offensive operations when considerably under strength, and therefore their densities of forces and weapons were usually low -- on the average approximately 4-5 tanks per kilometer of frontage. Consequently the defense was most frequently of a focal nature with establishment of a system of tank-killing areas. Tank ambushes were extensively employed, minefields would be planted, and maneuver of forces and weapons would be specified.

As a rule, tank corps and brigades in the past war, when turning to the defense in conditions of close contact with the enemy, would immediately proceed with organization of a fire plan, with field fortification and laying of antitank minefields. A strong reserve to execute counterattacks was usually established taking into account a wide combat frontage and the presence of gaps in the corps. When possible, mechanized brigades and motorized rifle battalions would be assigned to the forward echelon of tank corps, while tank subunits and units would be assigned to the reserve (support echelon).

Sometimes artillery groups, groupings of air defense weapons and reserves of special troops, particularly important among which were antitank reserves and mobile obstacle detachments, would be established in the defense.

The grouping of tank troops in the defense would be positioned within the designated zones, sectors, or areas. Company strong points unified into battalion defended areas (Figure 6.6.2) comprised the foundation of positions established in the defense.

Strong points and defended areas are organized taking into account the conduct of all-round defense. Tanks in strong points, just as the strong points proper, are positioned so that the enemy cannot discover their fire plan. The gap between tanks is 150-200 meters or more. Each tank prepares a primary and alternate emplacement in its position. Natural hollows and shell craters are selected for rapid preparation. Emplacements can be dug out by crews manually, sometimes with

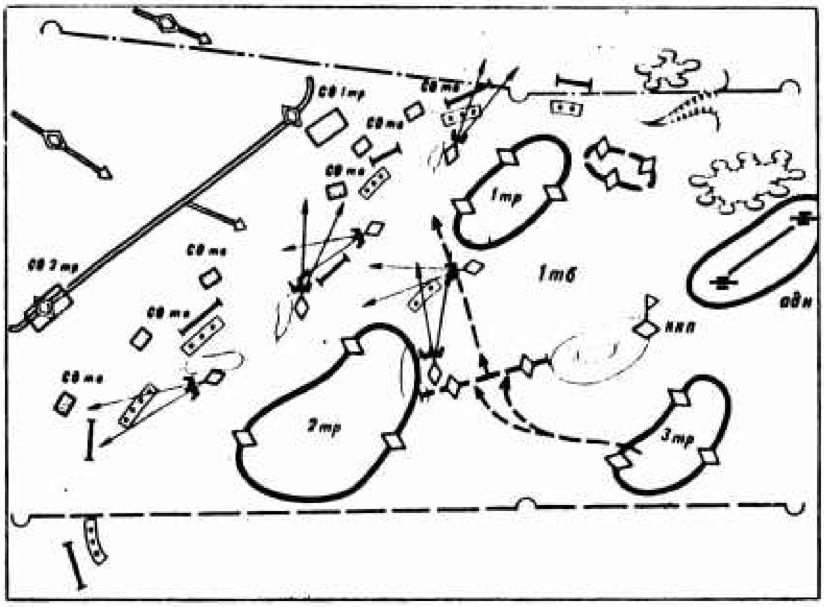


Figure 6.6.2. Tank Battalion Defended Area (variant)

CO -- outposts; тр -- tank company; тв -- tank platoon; тб -- tank battalion; КНП -- command and observation post; адн -- artillery battalion

---

the use of explosives, while earth-moving equipment is employed for digging emplacements if situation conditions permit.

As we know, during the war tank units would be assigned a sector for defense, and combined units -- a zone. Positions for artillery, air defense weapons, etc would usually be selected and designated within the boundaries of sectors and zones.

One of the most important questions pertaining to organization of defense is highly efficient fire planning. The fire plan in the defense consists in preparing organized delivery of effective fire on the enemy, following an integrated plan, by all available weapons on avenues of approach to the defense, and in creating solid barriers of fire of all types ahead of the forward edge of the battle area, on the flanks and at depth in friendly troop dispositions, as well as rapid concentration of fire in any threatened direction or sector. A fire plan is based on close coordination of all types of weapons, figuring the delivery of heavy airstrikes, in combination with a system of artificial and natural obstacles.

Depending on what weapons the defending subunit or unit (combined unit) has at its disposal, appropriate demands are imposed on the fire plan under present-day conditions. In the past war the most important of these demands included capability to destroy hostile offensive weapons and to deliver effective fire on enemy forces in concentration areas and during deployment for the assault, to suppress artillery, air defense weapons, enemy command and control facilities, to support defending subunits in their positions, and during the conduct of counterattacks the ability to repel a massed assault by enemy tanks and infantry and to destroy his maneuver forces.

A fire plan should ensure decisive destruction of a penetrating enemy and reliable cover of gaps in the dispositions of the defending troops, their flanks, artificial obstacles and areas subjected to strikes by weapons of mass destruction.

Under conditions of massed employment of tanks and other armored vehicles, organization of antitank fire is of exceptional importance. It is correct to consider antitank fire today the foundation of the fire plan of a defending subunit and unit.

In order to achieve a high effectiveness of fire, tanks in company strong points and battalion defended areas are positioned with consideration of capability by the enemy to hit tanks and other targets at maximum range, establishment of the highest density of antitank fire immediately ahead of the forward edge of the battle area and in gaps between tank positions and strong points.

Tank positions are selected in such a manner that they can deliver close-range concentrated fire, cross fire and flanking fire at assaulting enemy tanks. So-called dead space, where terrain is not under observation and is not covered by fire from primary positions, is also considered when positioning tanks.

The greatest density of fire is established in the zone of massed antitank fire. The range of effective tank fire against such targets as tanks, ICV, and armored personnel carriers comprises the depth of this zone. In addition, subunits (platoon, company) prepare concentrated fire at a greater range than the range of fire of an individual tank.

In the past war a fire plan would be set up immediately, on the basis of the combat decision, with subunits and units moving out to their designated defended areas and sectors. It would be set up simultaneously with field fortification. Principal attention would be devoted to precise determination of the fire missions assigned to each tank, antitank gun, antitank weapons and subunit as a whole. For example, reference points would be designated ahead of the position of each tank, gun, and antitank weapons, distances to them would be measured, and tank commanders would prepare range cards. Roving weapons, including tanks, were extensively employed in the defense.

Field fortification includes preparation of primary and alternate positions for tanks, antitank and other weapons, as well as artillery, and construction of shelters for equipment and personnel. If time is available, firing lines and counterattack lines as well as routes of advance to them are prepared. All installations and vehicles should be immediately camouflaged.

When time is limited, priority jobs include construction of artificial obstacles, including laying of antitank minefields ahead of the forward edge of the battle area, on the flanks and in gaps. According to the views of foreign military experts, it is advisable to provide for remote mining of the terrain (by aircraft, artillery) on the far avenues of approach to the defense and on the enemy's routes of advance.

Naturally field fortification cannot always be accomplished in full volume when time is limited. Therefore in the past war principal efforts in all instances would be concentrated initially on digging emplacements for forward-echelon tanks

and antitank weapons and on laying minefields. This work is usually performed by tank and antitank weapon crews. If situation conditions permit, engineer equipment and explosives are utilized for this work. In all cases engineer work is performed with maximum intensity on tank-threat axes.

The system of artificial obstacles is established in conformity with the general plan of action in combination with the fire plan, natural obstacles, and taking into account maneuver of friendly troops.

Determination of the procedure and sequence of mounting counterattacks is an important element of the defense plan. During the Great Patriotic War, favorable directions and lines of shift to a counterattack would be designated in the battalions, brigades, and corps, proceeding from the probable main axis of enemy advance and the composition of forces and weapons assigned to the support echelon. Directions of counterattack would be designated with the aim of mounting a surprise tank attack into the flanks of a penetrating enemy force. In planning counterattacks, the procedure and sequence of support of these actions by airstrikes and artillery fire would be determined. Appropriate missions would also be assigned to the forward-echelon forces and weapons pertaining to supporting a counterattack by support-echelon forces.

Defensive planning is usually performed by map, and combat missions are also assigned to subordinates by map. When time is limited, missions are usually disseminated by concise operation orders. Technical means of communication, primarily radio, are employed to transmit them.

In the interests of the fastest possible dissemination of missions, operation orders are simultaneously issued by the commander and by his staff on the commander's behalf. In all cases missions (according to the experience of the war) would be assigned on a priority basis to those subunits and units which were to be the first to move to the defensive lines, as well as those weapons which supported seizure of designated defensive lines and consolidation of troops on them. Forward detachments (advance guards) would frequently be dispatched to capture a designated position and to ensure maximally unhindered approach of the main forces to that position. These detachments would usually contain tank subunits or units reinforced by artillery, antitank and combat engineer subunits, and air defense subunits.

In conditions where reconnaissance would establish that the enemy was approaching a defensive line, covering forces consisting of tank subunits and units would sometimes be sent forward to delay the enemy in reaching this line. By aggressive maneuver actions and mounting surprise attacks on the approaching enemy, they would force him to deploy his forces and engage them while on the avenues of approach to the defense.

In order to ensure successful consolidation of a subunit in a position, airstrikes and artillery fire are delivered on an opposing enemy force, especially its weapons.

When shifting to the defense in conditions of close contact with the enemy, it is difficult to organize advance reconnaissance and mutual support on the terrain. Therefore in a number of instances the specific features of the terrain cannot always be fully taken into account and in relation to all questions. Some items,

especially questions such as organization of the fire plan, field fortification and mutual support require refining after the forces and weapons assigned to these areas move out to their positions. In these conditions the commander organizing defense can perform a detailed personal reconnaissance and detail matters of mutual support on the terrain, as a rule only on the anticipated main axis of enemy advance, on the boundaries between forward-echelon subunits, and on axes of counterattacks. He usually performs this job at the command posts (in areas, sectors) of subordinate subunits and units.

Organization of technical and logistical support is extremely difficult during a turn to the defense in the course of conduct of an offensive operation. Taking into account the fact that forces have become below strength in the course of preceding actions, measures are taken to repair damaged tanks and other weapons as quickly as possible, to reammunition and refuel. These measures, as indicated by the experience of the past war, would be accomplished not only by hauling supplies up from the rear but also by redistributing ammunition and fuel within units and subunits, with the aim of supplying on a priority basis those which are defending in the forward echelon on the anticipated main axis of enemy advance.

In cases where certain units and subunits have sustained heavy casualties and cannot perform new missions, they would be consolidated into composite units, or other units and subunits would be brought up to strength by adding the weapons remaining from other units and subunits.

The procedure of organizing the defense can be somewhat different out of contact with the enemy, especially when sufficient time is available to carry out requisite measures. The defense plan under these conditions is also set up by map, but it is subsequently detailed on the terrain, and only after this are missions assigned to subordinates. Missions in the Great Patriotic War were assigned in the form of an operation order summoning subordinate commanders to headquarters or directly to the terrain in the defended area. In this case, when combat missions would be assigned to subordinate commanders, as a rule detailed instructions would also be given on the spot pertaining to mutual support, fire planning, and field fortification.

During the Great Patriotic War such a method of organization of defense was practiced fairly often, especially when troops would first have to redeploy and execute a march in order to reach the defensive line. Under these conditions the commander would sometimes go out to the specified position in advance and perform the requisite work there prior to arrival of subordinate forces and weapons.

If insufficient time was available for organizing defense, the parallel work method would also be employed in turning to the defense out of contact with the enemy, just as under conditions of contact with the enemy.

Thus organization of defense in tank units and subunits is usually accomplished quickly, is distinguished by a high degree of complexity and requires considerable skill on the part of commanders, staffs, and all personnel.

4. Conduct of the Defense by Tank Troops

The character of conduct of the defense by tank troops depends on the conditions of the situation in which they repel an enemy attack. In some instances an enemy force in contact with defending units passes to the offensive, while in other cases it is forces advancing from depth.

In cases where it is anticipated than an enemy force in contact (following redispositioning, bringing up reserves) will pass to the offensive, one important mission of the defending forces is prompt detection of the enemy's readiness to attack. In the past war, for example, reconnaissance of the enemy was continuously conducted for this purpose; all his movements were taken into consideration, his capabilities and probable timetable of readiness to pass to the offensive would be analyzed, and measures undertaken to determine his immediate preparations for delivering fire and commencing the assault. All enemy actions which were the most insignificant at first glance would be carefully considered and estimated during this period: intensification of reconnaissance efforts, occupation of shelters, cessation of movements along the front, appearance in the enemy's dispositions of categories of personnel not noted previously (on the basis of uniform, quantity), massing of troops in the forward echelons, in the closest shelters, changes in radio traffic, etc. Captured prisoners and documents are important sources for determining the enemy's preparedness to attack.

Determination of the time of the enemy's commencement of an offensive operation was one of a number of particularly important factors influencing subsequent actions by the defending forces. As the time of possible enemy shift to the offensive approaches, the degree of readiness of the defending troops to repel him also increases. Surveillance is stepped up, weapons are readied for beating the enemy with delivery of fire, and all weapon and vehicle crews take their places.

In the opinion of foreign experts, after determination of the time at which the enemy may pass to the offensive (commencement of preparatory fire), it is sometimes advantageous for the defending force to conduct counterbombardment. Surprise airstrikes and artillery fire can inflict damage on weapons and casualties on forces preparing to commence the assault, putting them out of action and destroying their capability to commence the attack in an organized fashion. It is believed that in a number of cases such counterbombardment can not only lead to substantial enemy casualties but can also break up his attack. Foreign experts believe that counterbombardment will be particularly effective in cases where enemy command and control facilities are hit, as well as nuclear weapon delivery systems, air control facilities, artillery in firing positions, and tanks.

In the Great Patriotic War Soviet forces frequently conducted counterpreparation. The experience of the war indicated that when defending forces succeeded, with the aid of well-organized reconnaissance, in detecting enemy preparations for an attack, the most favorable conditions were ensured for successfully repelling enemy assaults. And even in a situation where counterpreparation was not conducted against the enemy, defending forces achieved considerable success with advance detection of the enemy's readiness to attack.

An enemy force which has commenced an attack is repulsed by fire delivered by all available forces and weapons.

Attacking tanks and infantry mounted on ICV and armored personnel carriers are destroyed with tank fire, by concentrated fire of subunits beginning at long range, and subsequently, as the enemy approaches the forward edge of the battle area -- by single-round fire. ATGM deliver fire at maximum range.

When the enemy reaches the forward edge of the battle area, his assaulting tanks and ICV (APC) are destroyed by fire delivered by tanks, ATGM and antitank guns brought to a maximum volume of fire.

Foreign military experts believe that in conduct of defense in conditions where an enemy approaching from depth is to be repelled, the previously adopted plan to deliver effective fire on the enemy on the far avenues of approach is refined on the basis of obtained intelligence. They assume that during this period the enemy will be hit by nuclear weapons and airstrikes on approaching rivers, road junctions, defiles, and during movement through forest and other areas where, in addition to inflicting damage, his maneuver can also be restricted and his advance delayed.

During the past war powerful strikes were mounted on the enemy as his main forces reached attack positions and deployment lines for initiating the attack. Prompt delivery of effective fire on enemy artillery, command and control facilities substantially diminished his capabilities to deliver fire on the defending troops, and there would be a possibility of significantly weakening him and sometimes breaking up the attack. The procedure of delivering fire on an approaching enemy force was approximately the same as depicted in Figure 6.6.3.

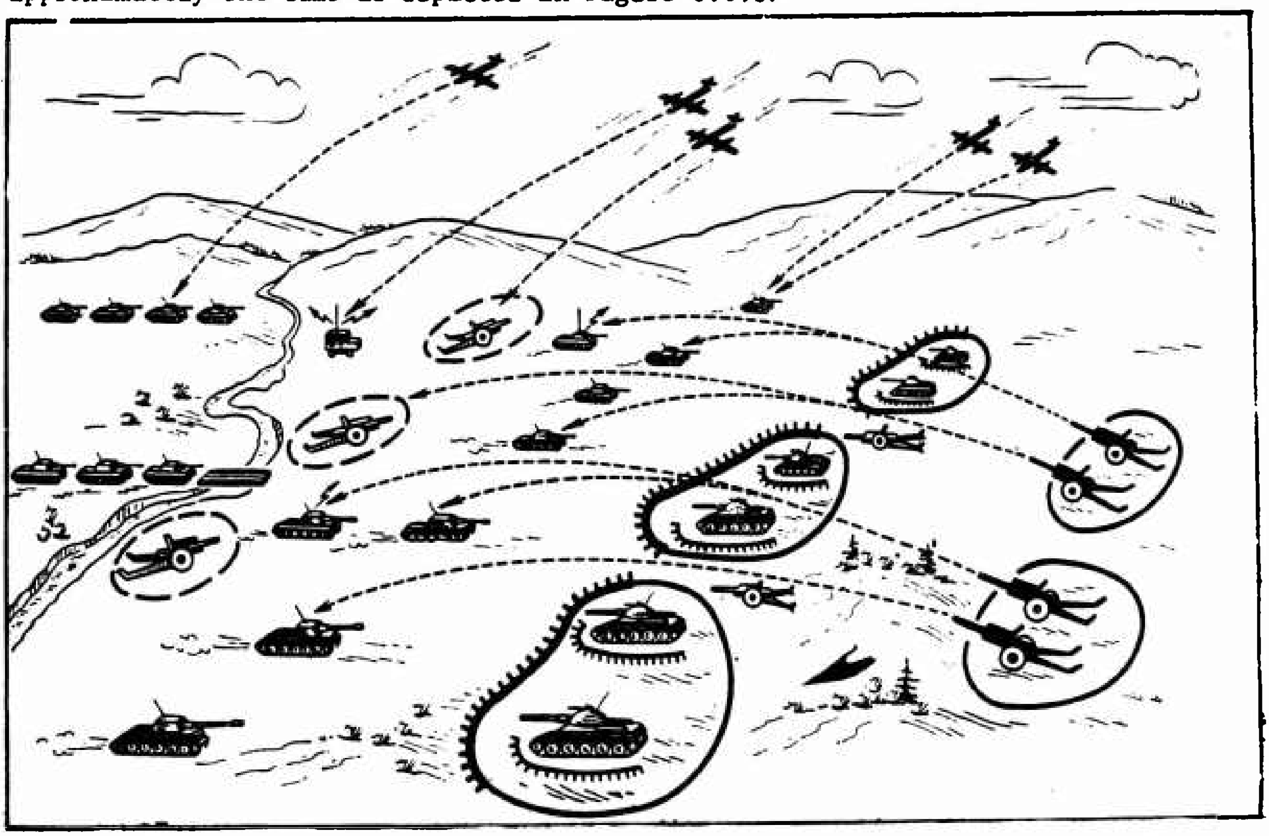


Figure 6.6.3. Hitting the Enemy as He Advances and Deploys for the Attack (based on war experience)

Just as in conditions of repelling an enemy force which is commencing an attack from close contact, counterpreparation was also specified during the war years against a deployed enemy. Sometimes it was considered possible, following counterpreparation, to attack the enemy with a tank force specially designated for this mission and usually established from support-echelon (reserve) forces of the defending troops.

In the past war such counterattacks were usually executed in cases where the attacking enemy force did not possess substantial numerical superiority, was isolated from other forces, or was stopped ahead of the forward edge of the battle area. It was considered that an attack on the enemy ahead of the forward edge of the battle area was evidently advisable only in cases where the forces and weapons involved could execute a planned maneuver secretly, that is, execute it with the element of surprise.

Based on the experience of the war, prior to commencement of the assault by the enemy main forces, the defending forces and weapons would observe maximum camouflage and concealment of actions, delivering fire on enemy reconnaissance and forward subunits from temporary or alternate positions, from defilade, from ambush, by roving tanks and other weapons.

As the enemy main forces reach the forward edge of the battle area, all tanks, guns, and antitank weapons of forward-position company strong points open fire on the assaulting tanks and infantry. Artillery also continues delivering fire on the enemy from indirect fire positions, bringing maximum volume of fire to bear on the main forces axes of attack. Fire is delivered with the objective of stopping the enemy ahead of the forward edge of the battle area, forcing him to give up continuation of the assault and withdraw to his initial position. Combat actions to repel enemy assaults are the most critical, and therefore they are conducted with the greatest intensity and determination, holding an occupied position even when the enemy bypasses. During this period tanks fire from their main positions, providing one another with mutual support and cover.

Artillery and all other weapons, during the enemy's assault phase, primarily deliver fire only on the directly attacking enemy, concentrating it for the most part in those sectors where he threatens to rupture the defense and advance to depth or turn the flanks of the defending subunits. Penetrating enemy tanks are destroyed with fire by tanks, ATGM and other weapons positioned in depth and on the flanks of the defending forces.

Based on the experience of the war, mobile obstacle detachments and antitank reserves would advance in sectors where the enemy had penetrated the defense, and when necessary, subunits and units from the support echelon (reserve) or from adjacent sectors would also advance in these sectors. Maneuver of forces and weapons was usually undertaken at the decision of the senior commander, and sometimes independently as well by decision of commanders of subordinate subunits and units. Simultaneously artillery fire would commence against enemy forces operating in the breakthrough sector, and airstrikes would be delivered. As a rule the enemy's advance would be stalled as a result of such actions by the defending forces.

In addition to execution of maneuver by a part of the forces and weapons in order to close breaches or reinforce forward-echelon troops on the main axis of enemy advance, the defending forces would also usually prepare for a more complex maneuver. In the course of an offensive operation, the enemy may abruptly change the direction of concentration of main efforts. In this situation the defending forces will also need to maneuver to a new sector. During the defensive fighting at Kursk in July 1943, for example, when the advancing enemy shifted his main efforts to a new sector, the VI Tank Corps executed a maneuver toward the exposed left flank with its reserve (112th Tank Brigade), right-flank brigade (200th Tank Brigade) and its support-echelon 22d Tank Brigade (Figure 6.6.4), as a result of which the enemy was unable to achieve success on the battlefield.

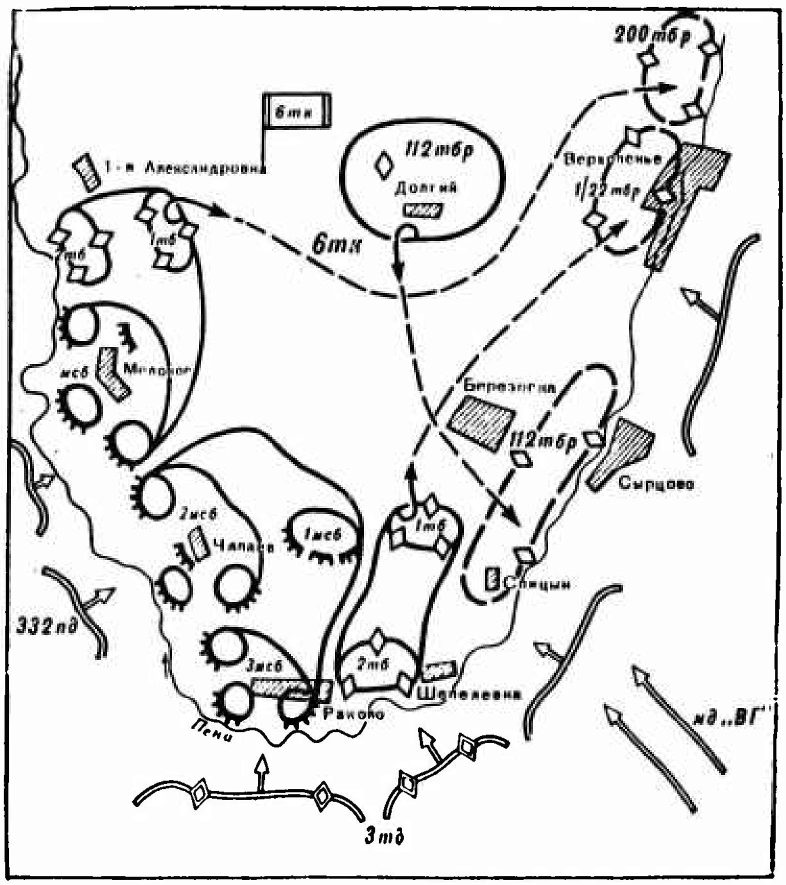


Figure 6.6.4. Defensive Arrangement of the VI Tank Corps in July 1943

mk -- tank corps; mb -- tank battalion; mcb -- motorized rifle battalion; mbp -- tank brigade; md -- mechanized division

When executing such a maneuver, tanks would swiftly advance to new lines and positions and would engage without a halt or pause. In all cases, however, thoroughly organized reconnaissance and security were required, especially during night actions.

In some sectors the enemy may sometimes penetrate the defense and bypass individual strong points and areas. In such a situation the defending forces endeavor to stop the enemy and prevent him from advancing swiftly to depth and from widening the penetration toward the flanks.

According to the view of foreign experts, effective fire is delivered on a penetrating enemy force by all the weapons of the defending force, both forward and support echelon. Minefields are laid in those sectors where enemy tanks have achieved penetration. Artillery fire and airstrikes are delivered on large penetrating tank forces.

Forces and weapons which end up to the rear of the penetrating enemy force stubbornly hold their occupied positions and with aggressive actions help the main forces repel the enemy attack.

Based on the experience of the past war, the main efforts of forward-echelon defending forces during this period of combat should be concentrated on solidly holding the most advantageous positions and areas, in order to ensure favorable conditions for engagement of defending forces and weapons in position at depth and to counterattack with support echelons and reserves. It was believed that firm retention by forward-echelon subunits and units of important areas and positions ahead of the battle line and on the flanks of the penetrating enemy force can promote to a significant degree the successful defeat of this enemy force in detail by support-echelon counterattacks.

Counterattacks (counterthrusts) were the most decisive and aggressive form of engagement of a penetrating enemy force during the war years. A powerful surprise attack by tanks, launched following a heavy-volume artillery bombardment, especially into the flank of a penetrating enemy force, would lead to the enemy's total defeat in short order.

The decision to counterattack would be made taking into consideration the course of combat and a number of other conditions. The success of counterattacks depended in large measure on the quantity and composition of enlisted forces and weapons, on the degree of established superiority over the enemy in the sectors where counterattacks were launched, correct selection of direction and moment of attack, as well as reliability of delivery of effective fire on the penetrating enemy force.

The experience of the past war indicated that almost the total forces and weapons of support echelons (reserves), as well as a part of forces from less active defended areas would be enlisted for counterattacks (counterthrusts). As a rule, all tanks would be utilized for counterattacks in the defense of rifle divisions and corps. Primarily tank and motorized rifle (mechanized) brigades comprising the combined-arms reserve were utilized in tank corps for the conduct of counterattacks. In February 1944, for example, in the 6th Tank Army in the Korsun'-Shevchenkovskiy Operation, a counterthrust was mounted by two tank and three motorized rifle brigades; in the 2d Tank Army in the Lublin-Brest Operation in August 1944 -- two tank brigades and two self-propelled artillery regiments; in the 3d Guards Tank Army in the Lvov-Sandomierz Operation in August 1944 -- two tank brigades and one self-propelled artillery regiment.

The time when the attacking enemy was halted by fire delivered by forward-echelon subunits, his combat formations disarrayed, reserves expended or delayed on the approach, and favorable conditions were created for the concealed advance of counterattacking forces and weapons into the enemy's flank was considered a favorable moment for launching a counterattack (counterthrust).

In conditions of deep enemy penetration it is advantageous to attack him from the rear as well with a part of the defending forces. In the defensive operation of the 2d Tank Army in the Lublin-Brest Operation in August 1944, for example, a counterthrust was launched from the flank and rear against the enemy's 19th Panzer Division, which had penetrated the defense. As a result the penetrating enemy was cut off from his remaining forces and destroyed. When the enemy penetrates on a broad frontage, tanks also sometimes counterattack frontally as well.

An important condition for successful conduct of a counterattack by support-echelon (reserve) tank subunits and units is their close coordination with forward-echelon forces.

In the past war it was believed that in order to ensure unhindered advance and deployment of counterattacking forces, forward-echelon subunits and units should firmly retain positions favorable for this (Figure 6.6.5). The trace of the held lines and positions should promote execution of a counterattack by support-echelon (reserve) tanks on terrain favorable for their actions and delivering an attack into the enemy's flank or rear.

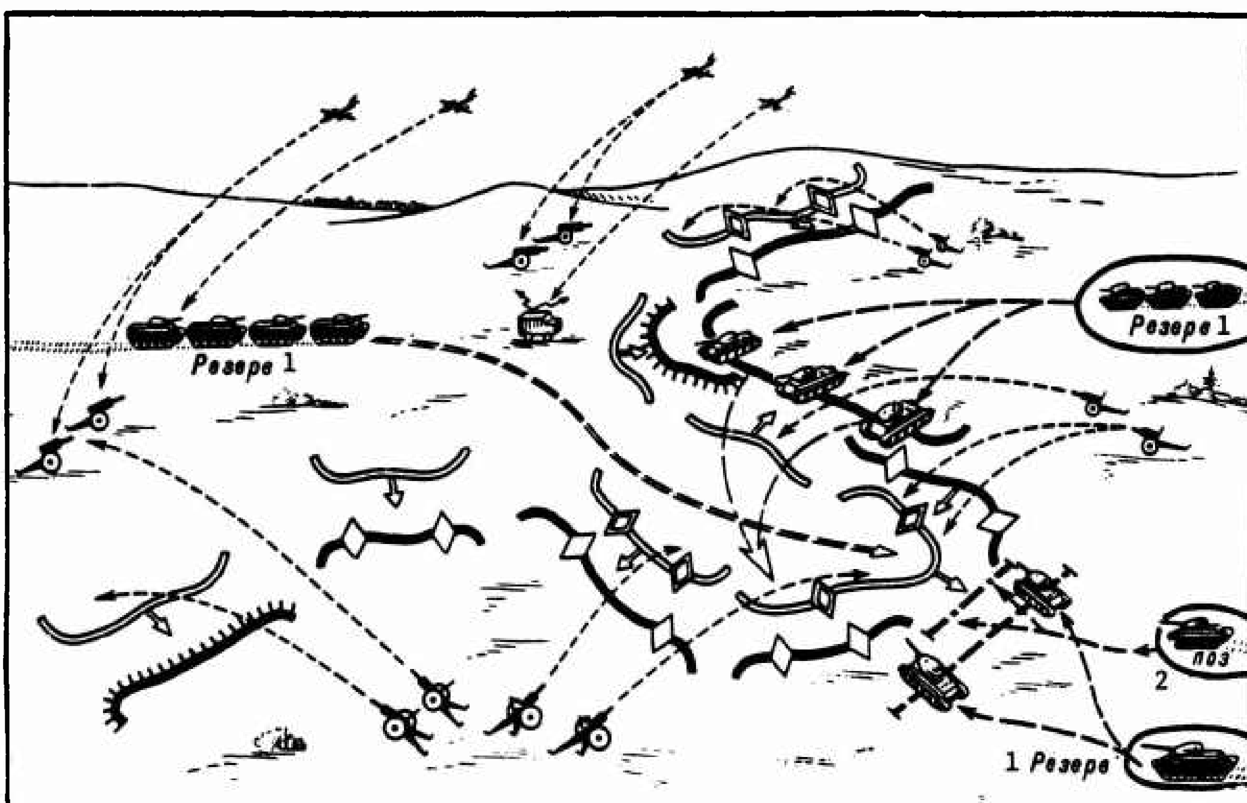


Figure 6.6.5. Defeating in Detail a Penetrating Enemy Force (based on war experience)

Key to Figure 6.6.5:

1. Reserve
2. Mobile obstacle detachment

During preparation for a counterattack (counterthrust), the advancing enemy would be hit by artillery fire, airstrikes, and other weapons. If the enemy had not yet expended his reserves, such pressure would be brought to bear on him that up to launching of the counterattack the enemy would be unable to engage them for the purpose of building up the efforts of his attack echelon.

Tanks launch the counterattack immediately following delivery of a heavy volume of fire on the opposing enemy force. In connection with the fact that speed and offensive surprise are one of the conditions of successful execution of a counterattack, tanks proceed swiftly, moving at maximum speed, and deliver fire while rolling. The experience of the past war indicated that counterattacking tanks achieve the greatest success with continuous support by artillery fire and airstrikes and with close coordination with air defense weapons.

In those cases when the advancing enemy possesses considerable forces and the counterattack is launched frontally, tanks initially hit the enemy with a heavy volume of stationary fire (on the deployment line) and then swiftly initiate the assault.

Forward-echelon subunits, during the conduct of counterattack by the assets of the higher commander (reserves) across the occupied area, also commence a counterattack. In sectors where launching a counterattack is not possible, defending subunits deliver fire on the opposing enemy force during this time and prevent him from maneuvering to another sector.

In the past war, a successfully executed counterattack would develop as a rule into defeat of the advancing enemy in detail and restoration of the defense. In favorable conditions, sometimes troops would also initiate a decisive offensive following a successful counterattack. In a number of cases actions by the opposing sides in the course of a counterattack may assume the form of a meeting engagement, and for large forces -- an encounter battle, such as, for example, the encounter battle of the 5th Guards Tank Army in the Battle of Kursk in 1943 during execution of a counterthrust near Prokhorovka.

The enemy may deliver airborne assault forces in the course of an attack. Tanks possess considerable capabilities to engage such forces, but this requires prompt detection of enemy preparations to land assault forces and organization of their annihilation.

The most effective are actions by tank units to destroy an airborne force at the moment it lands, when it has not yet organized defense of the captured area. In this case tank subunits can operate successfully in crushing the assault force. One should bear in mind, however, that an airborne assault is usually supported by heavy covering fire from the air -- by fixed-wing aircraft, helicopters, and other weapons.

In the course of defensive actions tank units may sustain losses as a result of enemy artillery fire and airstrikes. In many cases in the past war, however, tanks

in the defense continued delivering fire, even after taking damage which had destroyed their mobility.

In the past war tank troops successfully conducted defensive actions under special conditions as well. In this case, however, their actions were characterized by a number of specific features. For example, in connection with limited tank-accessible terrain when conducting defense in mountains, arctic regions, mountain-taiga or mountain-desert terrain, tanks operated primarily on separate axes, for the most part in small groups, as a rule capturing important road junctions, mountain passes, ravines, and defiles between lakes. Defense would be set up chiefly in the form of separate strong points or defended areas, usually with substantial gaps between them. As a consequence of varying terrain accessibility to tank actions, the overall defense frontage of subunits and units frequently was greater than under normal situation conditions.

Under these conditions, due to the complexity and sometimes the impossibility of lateral maneuver, it was necessary to distribute forces with consideration of ensuring a high degree of independence of troops in each defended sector.

Support echelons and reserves were usually positioned in several areas. Mobile obstacle detachments and antitank reserves were similarly dispositioned. As a rule tanks and tank subunits operated jointly with rifle subunits.

During tank defense in mountain terrain, extensive maneuver in the fire plan of tanks (trajectories) and other weapons is accomplished, with multitiered fire on tank-threat axes and artillery fire on potential axes of enemy turning movement around the flanks of the main forces and in gaps between units. Special attention in mountain operations during the war was focused on fire planning for delivering effective fire on the enemy in dead spaces. Tank ambushes were extensively employed in mountains, both ahead of the forward edge of the battle area and at defense depth.

It is believed abroad that in mountain operations, operations in arctic areas, mountain-desert and forested mountain terrain, employment of engineer vehicles and explosives is required in greater volume for digging tank emplacements. More time is required for the conduct of engineer activities.

When combat is conducted under these conditions, tanks inflict greater damage on the enemy with stationary fire, since their maneuver is restricted and requires more time than under normal conditions. Due to the ruggedness of the terrain and abrupt changes in conditions of observation and delivery of fire when a tank or tank unit changes position by even a small distance, reliable mutual support and covering of actions by fire and maneuver of adjacent tanks and subunits are required.

Counterattacks are for the most part launched along prior specified and prepared axes. But usually more time is required for their organization and execution, and exceptionally thorough coordination of actions by the counterattacking forces and forward-echelon subunits is essential. Thus decisive and aggressive actions by tanks in the defense can make it highly stable and solid. With skillful utilization of favorable terrain conditions, defense of tank troops can become impenetrable. Successful accomplishment of missions in the defense is achieved by correct

utilization of the performance characteristics of tanks, thorough organization of tank actions on the basis of comprehensive and thorough evaluation of concrete situation conditions, and skilled organization of fire planning in combination with artificial obstacles and extensive maneuver.

Chapter 7. CONTROL

1. Essence of Control in Modern Combat

The modern tank troops engagement takes place in complex situation conditions, is dynamic and of brief duration. Its success depends on many factors, a principal position among which is occupied by firm and continuous troop control. Control is the practical activity of commanders and staffs in the area of preparation and organization for combat and direction of troop efforts toward successful execution of the combat mission.

Measures to prepare troops for action include maintaining a high level of combat readiness, planning and organization of troop actions, including assignment of missions, organization of mutual coordination, comprehensive support, as well as monitoring activities and assistance to the troops. In the course of performance of various actions by troops, troop control includes maintaining capability effectively to carry out combat missions taking into account all situation changes and new tasks.

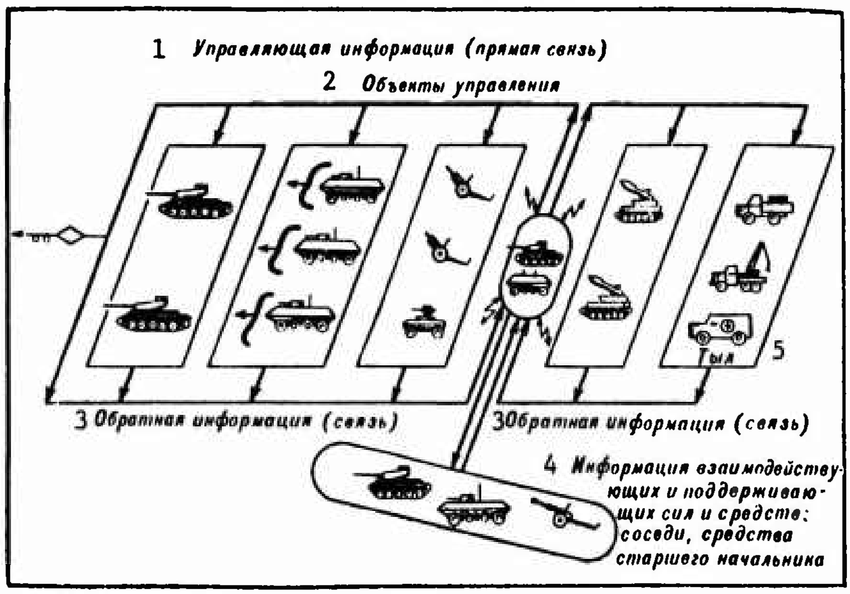


Figure 6.7.1. Block Diagram of Information Process in Battle (according to foreign views)

Key to Figure 6.7.1 on preceding page:

1. Control information (direct linkage)
2. Objects of control
3. Feedback information
4. Information of coordinating and supporting forces and weapons: adjacent units, assets of higher commander
5. Rear services

Successful resolution of problems pertaining to troop control prior to commencement and in the course of combat operations is based on collection and study of situation data at all echelons, prompt and timely decision-making or decision refinement, assignment or refinement of missions, coordination of actions of forces and weapons in conformity with the objectives of combat and the general plan of its conduct. Figure 6.7.1 contains a block diagram of the information process in combat (according to foreign views).

A high degree of combat readiness on the part of control agencies and efficiency in their work constitute extremely important demands on troop control under conditions of a rapidly and abruptly changing situation and highly-dynamic tank troops combat operations. Control should be continuous, firm, flexible, and with the element of secrecy.

Continuity of control is achieved by an aggregate of measures, the most important of which are constant knowledge of the situation, prompt and timely decision-making and rapid assignment of missions to subordinates, which depends on the availability of communications, skilled positioning of control facilities and their displacement in combat. In addition, continuity of control is secured by organization of effective measures to protect friendly radio electronic facilities (radio facilities) and systems from hostile electronic countermeasures. Of great importance for maintaining continuous control are rapid transmission of commands from one point to another and restoration of disrupted control.

Firmness of control consists in commanders at all levels displaying initiative, persistence and decisiveness in executing the designated plan of action.

Flexibility of control consists in rapid response to situation changes and in prompt and timely refinement of a prior adopted decision, missions, sequence and procedure of mutual support.

Secrecy of control consists in keeping secret all measures pertaining to preparation for and conduct of combat operations and execution of requisite camouflage and concealment measures.

2. Organization of Combat Operations in Tank Troops

Organization for combat operations of the subunit or unit encompasses the sum total of measures carried out by the commander, staff officers, chiefs of arms and services pertaining to decision-making, performance of various calculations, assignment of combat missions, organization of coordination, comprehensive support, control, as well as preparation of troops for combat operations, monitoring activities and assistance. All these measures are carried out on the basis of the commander's plan for the forthcoming operations.

The commander exercises control of subordinate troops personally and through his staff. He estimates the situation and makes his plan, assigns missions, organizes mutual coordination, issues instructions on the procedure of comprehensive support, monitors and verifies execution of combat missions by subordinate troops, and gives them requisite assistance. The commander informs his executive officer on the general plan of action and instructions given to subordinates.

As the experience of the war indicated, in tank troops all this work was conducted as a rule under conditions of limited time, frequently during movement, and not infrequently under hostile fire. The commander frequently lacks situation data for decision-making. Naturally the success of this work depends on the commander's level of training and preparation, on his experience and practical skills, and on his ability to act with speed, concentration, purposefulness, and innovativeness.

Staff efficiency is very important. Under conditions of a rapidly and abruptly changing situation and limited information for decision-making, calculation and intelligent risk, foresight, boldness and speed should be combined in the commander's work. Innovative resolution of all problems, activeness and initiative are among the most important demands on the commander's work in the area of troop control.

The concrete work methods of commanders and staffs at all echelons are determined primarily by time availability, level of officer training and preparation, and technical equipment of headquarters. In all instances this work is organized in conformity with the specific assigned combat mission and specific situation features.

The commander's combat plan should take into consideration the realistic combat capabilities of the opposing sides and be grounded on the principles of conduct of the modern combined-arms engagement. Naturally it should also correspond to the higher commander's concept and ensure maximum effectiveness of employment of weapons and combat equipment.

Decision-making is a complex, innovative process in the commander's activities. An important role in these activities is played by the method of planning.

In order to settle all essential questions as rapidly as possible, the commander should rely on the assistance of his staff and initiative on the part of staff officers, concentrating attention on the main points.

Planning is based on clarification of the assigned mission and the situation estimate. At the same time, commanders of tank subunits and units, when operating separated from other forces, frequently must make decisions without receiving missions from higher authority, especially if the situation changes rapidly and abruptly in the course of combat, as a consequence of which the necessity arises to introduce changes in actions, that is, perform a new mission. Such conditions are especially frequently created in tank troops during exploitation deep in the enemy's rear and during independent conduct of combat actions. Success in this instance is achieved by making bold plans with initiative, calculated to utilize the high mobility of tanks and swift actions with the element of surprise.

When receiving a mission, the commander usually clarifies it and determines the requisite measures which ensure fullest preparation for combat. The concrete

content of a combat plan is determined in the course of estimating the situation. One of the principal elements of the combat plan is the general plan of action, based on determining the procedure and sequence of defeating the enemy's main forces (whom to destroy, where, at what time, in what sequence, and in what manner). In addition, combat missions for subordinates and the procedure of organization of mutual support and control are generally determined in the plan.

In estimating the situation and planning an operation it is especially important correctly to consider the nature of the terrain, since the success of tank operations is determined in large measure by terrain accessibility to tanks. Combat planning is as a rule done by map. Personal reconnaissance on the terrain is performed if time is available. Combat missions and matters of mutual support in tank troops are usually communicated by map, and are refined on the terrain if commander's reconnaissance is performed.

Missions are disseminated to subordinates by operation orders and instructions, for which technical means are employed. The assigned combat mission is mandatorily redundant-recorded by headquarters in the form of written or graphic operational instructions. Missions are also sometimes communicated in person.

Securement of mutual support -- one of the most important conditions for achieving success in today's combined-arms engagement -- is one of the complex and specific items in organization for combat by tank subunits. It is a well-known fact that tanks are a powerful, potent weapon capable of accomplishing the most difficult combat missions. But the experience of wars, and especially the Great Patriotic War, as well as local wars in recent years has indicated that in order successfully to accomplish their combat missions, tanks require the closest coordination with the forces and weapons of other combat arms. Therefore in determining the procedure and sequence of tank actions, one usually considers the capabilities of motorized rifle subunits, air defense forces and weapons, artillery, air, and engineer subunits.

All matters of coordination and mutual support are determined so that subordinates are clearly aware of the fundamental essence of mutual support of forces and weapons in the forthcoming engagement and, on this basis, in the course of combat actions can independently, with innovativeness and initiative determine expedient actions by assets subordinate to them and coordinate them with other forces and weapons.

Such organization of mutual support is grounded on a clear understanding by all subordinate commanders of the higher commander's concept and the content of missions assigned to adjacent units, supporting and attached assets, as regards objective, place and time. Combat experience indicates that precise execution by troops of their assigned missions at all echelons has always been the foundation of successful troop mutual support.

An important part of the work of the commander and his staff in organizing for combat is determination of matters pertaining to comprehensive combat support. Principal measures pertaining to supporting troop combat operations include organization of reconnaissance, security, camouflage and concealment, protection against weapons of mass destruction, engineer, rear services, technical support, etc. Hydrometeorological and topographic support, as well as other types of support are assuming great significance under present-day conditions.

The commander determines the basic content of missions and measures pertaining to these items during his situation estimate. On this basis his staff and the corresponding chiefs of arms and services work out the specific content of measures pertaining to all forms of comprehensive support of troop combat operations.

Reconnaissance is particularly important for the success of tank combat. It is conducted in various ways, depending on who organizes it. For example, reconnaissance in tank subunits (platoon or company) is conducted principally by observation from each tank. Foreign military experts believe that in larger units special reconnaissance agencies can be detailed to conduct reconnaissance, agencies which employ various methods, including direction finding on operation of enemy installations, radio intercepts, capture of prisoners, etc. Intelligence-gathering activities are conducted as deeply and on as broad a front as possible.

Simultaneously with the commander's combat planning, his staff determines, taking into consideration previously performed calculations of distribution of assets, communications procedure and organizes monitoring of preparations by subordinates for combat.

Organization of communications occupies one of the most important places in determination by the staff of matters of control, especially ensuring continuity of control. The communications system should make it possible to notify troops quickly and to supervise them closely while bringing them to a state of combat readiness, to assign missions to subordinates in a prompt and timely manner, to inform adjacent units, to report the situation to the higher commander, and to ensuring maintaining continuous mutual support. In order to ensure that communications provide continuous and flexible troop control, they are organized taking into account operational-tactical conditions and the capabilities of communications personnel and equipment.

A most important demand on a communications system is ensuring its reliability.

As is noted in the foreign press, to achieve this a communcations system is organized in such a manner that requisite information can be transmitted simultaneously by several channels and by various means, so that commanders and staffs can maintain communications not only along the line of immediate subordination but when necessary also are able to establish contact with other echelons, both higher and lower, and with adjacent units. This made it possible, particularly during the war, to maintain reliable communications in case any control facilities were put out of action.

In connection with possible use of nuclear weapons by the enemy, military operations may occur in vast zones of radioactive contamination, during negotiation of which the distance between command posts may increase sharply. Maintaining communications in such cases during the war years was frequently accomplished by means of auxiliary communications centers and relay points.

Judging from information in the foreign press, the armies of the NATO nations devote considerable attention to electronic warfare. In connection with the considerable capability of modern signals intelligence equipment and jamming, maintaining stable communications requires taking appropriate measures to ensure reliable

communications with aggressive hostile jamming efforts, camouflage and concealment of command posts and operation of communications equipment. Essential elements include rapid transmission of information by communication channels, scrupulous observance of communication discipline, securement of troop control secrecy, and a sharp reduction in data transmission time.

The highly mobile, dynamic character of tank combat operations, frequent and abrupt situation changes dictate the necessity of setting up a communications system so that it ensures continuous and flexible troop control when shifting from one type of action to another without substantial system reorganization, since in most cases there will be no time available for this.

In order to accomplish this task it is necessary to maintain continuous, thoroughly organized communication both between command posts and between officials at command posts.

3. Control Agencies and Command Posts

Control is a process which encompasses an aggregate of measures, in the execution of which an appropriate place is occupied by control agencies and command posts established for directing combat operations.

The experience of the past war indicated that the principal control agency is the headquarters, through which the commander exercises supervision of subordinate forces and equipment. Prior to the commencement of combat operations the headquarters staff gathers information required for the commander's plan. Under present-day conditions, however, such extensive information is received by headquarters that communicating this information to the commander in its full volume can not only make his planning work more difficult but under conditions of limited time will prevent him from receiving it in a prompt and timely manner. Therefore, as was indicated by the experience of the war, it is important in preparing information for the commander carefully to select out that data which enables the commander to obtain the most important and essential information as rapidly as possible. For this purpose the headquarters staff during the war years would continuously prepare calculations pertaining to support of forces, relative strengths, movement and deployment of forces, and consumption of supplies.

On the basis of the commander's plan, his staff plans troop operations and measures pertaining to their comprehensive support, disseminates missions to executing entities, organizes intelligence activities, prepares for the conduct of reconnaissance, and ensures mutual support. One of the most important tasks of the headquarters staff during this period is organization of communications with subordinate and cooperating forces and facilities, with adjacent units and higher headquarters.

In conformity with the procedure of organization of control established by the commander, his staff provides for equipment, positioning and displacement of command posts. Headquarters, as a control agency, continuously monitors during combat execution by troops of their assigned missions on the basis of situation data obtained through communications channels set up for this purpose, and by observation by staff officers who personally visit the formations.

In connection with the fact that the situation changes rapidly in the course of combat operations, collection of information should be performed aggressively and continuously.

As an agency with the aid of which the commander controls subordinates, the headquarters staff at the same time should independently perform a number of control functions in development of orders and instructions issued by the commander, and sometimes in anticipating them, since the staff is not only an executive but also an originating agency. In conditions of highly dynamic actions, this aspect of staff activities is especially important and fundamental.

Command posts are established for the purpose of exercising supervision of troops in combat; a specific group of officials are located at these facilities. Command posts are equipped with various technical means of control and movement, and are also provided with service and support subunits.

The experience of combat operations in the past war indicated that efficiency and continuity of troop control depended in large measure precisely on the system of command posts, on their interrelationship and procedure of displacement. This system provided, in particular, for the existence at each level, beginning at the regiment (brigade), several control facilities, established by disposing in depth organic control personnel and facilities. Control facilities were subdivided into command posts (CP), observation posts (OP), and rear services control facilities (TPU). In addition, auxiliary command posts (ACP) would be established in the armies and sometimes in the corps.

The observation post was a command post element. The commander usually directed combat from a command post, where the majority of his staff were located, while for more detailed study of the situation he would travel to OP with a small team of staff officers, called the command group (CG).

The command post, observation post, and auxiliary command post were the forward control echelon. The rear services control facility was the second echelon of control. It supervised rear services subunits and establishments. This system of control facilities ensured a high degree of control survivability and flexibility.

Today usually a single control facility is established in the tank battalion in all types of engagement -- a command and observation post (COP). It is headed by the battalion commander (Figure 6.7.2). If the COP is put out of action, battalion control functions are assumed by one of the company commanders.

In units and combined units, according to foreign views, it is considered advisable for ease of control and to ensure a stability of control to establish a command post and forward (alternate) command post, as well as a rear command post (Figure 6.7.3); today the availability of helicopters enables the commander to control troops while in the air as well.

The command post is designated for immediate troop control. If there are several control facilities, that one at which the commander is located is considered the principal command post, for the commander alone has decision-making powers. The rear command post is usually established for supervising rear services subunits and units.

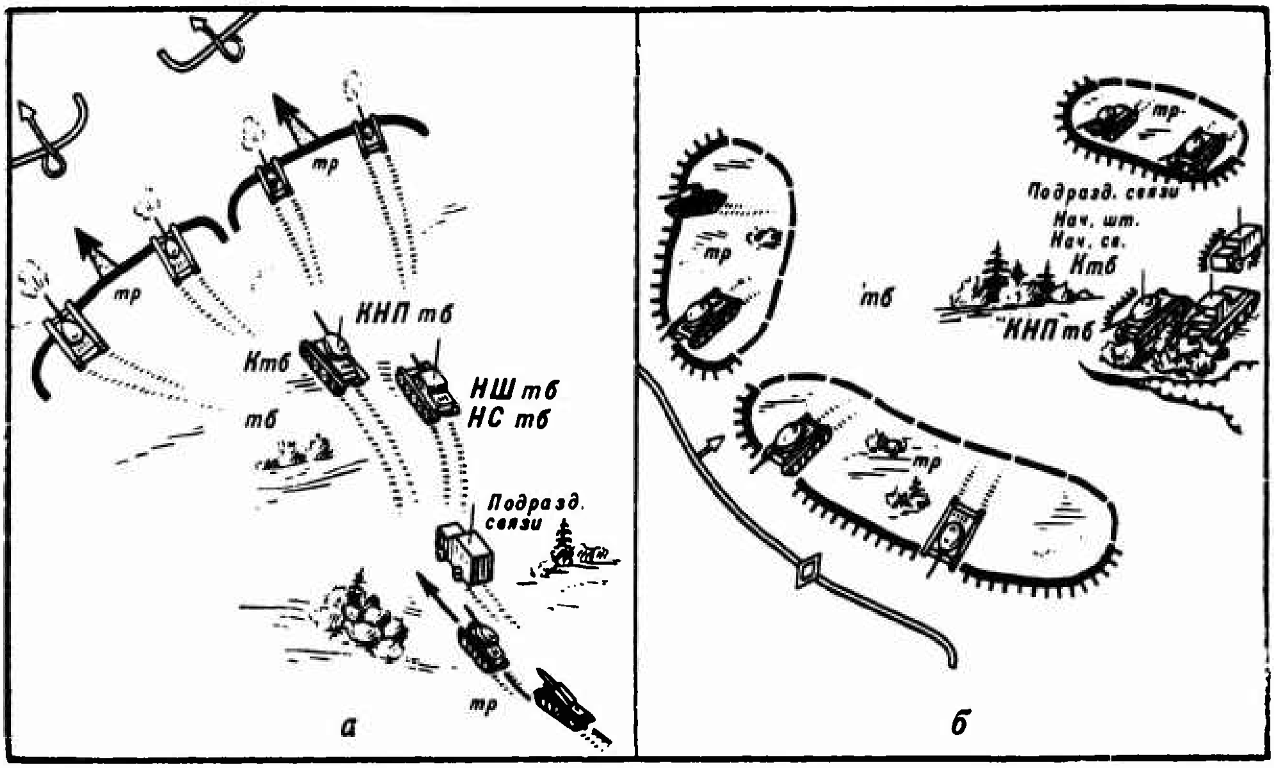


Figure 6.7.2. Tank Battalion Control Facilities

Key:

a.	In the offense	K.	Commander
b.	In the defence	KHП.	COP
mb.	Tank battalion	mp.	Tank company
HШ.	Executive officer	HC.	Chief of communications

Подразд. связи -- communications subunit

In tank troops command posts are as a rule made highly mobile. Toward this end they are set up with a limited number of personnel and equipment and are equipped with vehicles with good cross-country performance. A tank brigade command post in the past war, for example, contained 60-90 men, 20-25 various vehicles, and approximately 10 radio sets.* The tank corps command post was 50 to 100 percent larger. Such a large quantity of personnel and equipment was necessary at that time. It was considered, however, that these command posts were nevertheless unwieldy. Therefore command post command groups included the following: at brigade -- 5-7 men on 4-5 vehicles with 3-4 radios; at corps -- 8-10 men on 6-8 vehicles, with 5-6 radios. According to views abroad, a command post and observation post are set up at battalion, and in divisions -- a main command post, alternate command post, and rear command post. A combat operations control center is established at division for the period of a combat operation.

* See N. N. Popel'. V. P. Savel'yev, and P. V. Shemanskiy, "Upravleniye voyskami v gody Velikoy Otechestvennoy voyny" [Troop Control During the Great Patriotic War], Moscow, Voyenizdat, 1974, page 41.

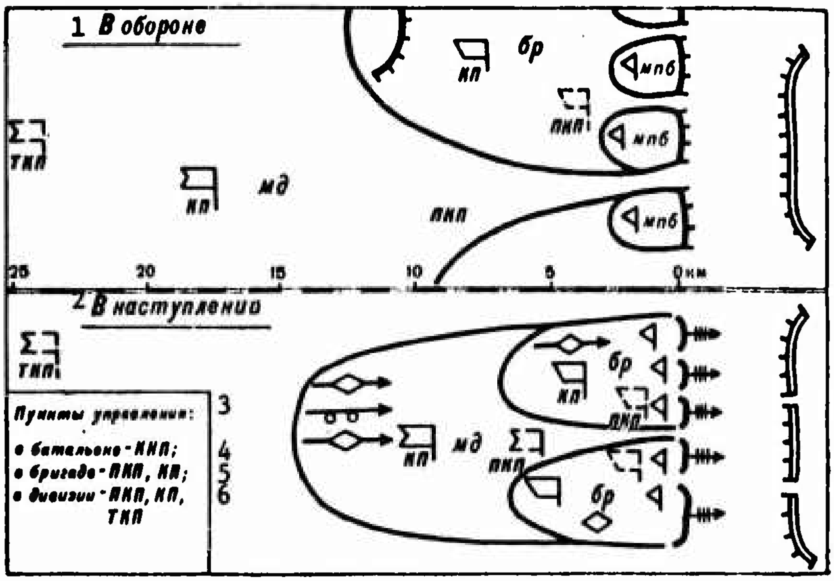


Figure 6.7.3. Command Posts in U.S. Army (variant)

Key:

1.	In the defense	4.	In the battalion
2.	In the offense	5.	In the brigade
3.	Command posts	6.	In the division
ПКП.	Forward command post	ТКП.	Rear command post
бр.	Brigade	КП.	Command post
МПБ.	Motorized infantry battalion	md.	Mechanized division
КНП.	Command and observation post		

Command posts are usually positioned and displace in forward echelon formations. The specific distance of command posts from forward subunits should ensure their safety and maintenance of stable communications with the troops. Bringing forward command posts (in the war, observation posts) closer ensures personal commander observation of the battlefield and permits maximum flexible and efficient control of subordinates. In the past war in an offensive operation of tank brigades, their command posts would be at a distance of 2-3 km, and 5-6 km for a tank corps, from forward subunits. In the defense, brigade command posts would usually be positioned beyond the first position, and corps command posts beyond the forward-echelon brigades. The distance between brigade and corps command posts averaged 5-10 km, and sometimes more.

Displacements of command posts in combat are accomplished as rapidly as possible, so that they can operate longer during halts. Work at command posts is conducted continuously, however, both in place and in movement. Time is gained during displacement of command posts by shortening time to set up and take down, as well as high rates of movement both on and off roads. In the past war, for example, tank corps command posts would be put up and taken down in 30-40 minutes.

During the war years, in order to ensure maximum survivability of command posts in position and during displacements, the requisite degree of dispersion of command post elements and concealment would be ensured, and measures would be taken

to maintain continuous communication with troops and higher headquarters and immediate transfer of control from one point to another.

Command posts are positioned and displace taking into account disposition of air defense weapons and security. During operation that radio communication mode is selected which gives away the position of control facilities to the least degree.

4. Technical Means of Control

Technical means of control include communications equipment and command-staff vehicles.

Communications equipment includes radio, radio relay, wire, mobile and signal equipment, as well as various equipment for information acquisition, processing, calculation and documentation.

Radio communications in tank troops is the most important and sometimes the sole means of controlling tanks and cooperating assets in the most complex situation. Radio communications, as was indicated by the experience of the past war, can be organized in radio nets and radio links, the number and composition of which will be determined proceeding from control requirements and availability of radio equipment.

In a tank battalion, for example, radio communication between the battalion commander and the higher commander and his staff is usually handled by appropriate radio nets. Communication with commanders of tank companies, platoons and tanks on the line, as well as the battalion chief of staff and technical observation post utilizes the battalion commander's radio net.

Frequencies are carefully distributed to ensure stable radio communications, and radio equipment at command posts is placed so that there is no mutual interference.

Wire communications in tank troops are employed chiefly in concentration areas, in the defense, as well as in command posts.

Mobile communications equipment will be employed in all types of combat activities of tank units and subunits, and signal equipment in subunits.

Combined employment of all means of communication makes it possible fully to utilize the positive qualities of each, to supplement one type of communication with another and thus to ensure high overall communications reliability.

The time factor is of prime significance in troop control. At the same time, the high tempo of conduct of tank combat actions sometimes requires that headquarters staffs be in movement for an extended period of time. Therefore command posts in combat units are mobile. Ensuring their mobility can be successfully accomplished with the aid of command and staff vehicles equipped with work stations for several staff officers, requisite observation and communication equipment.

Command and staff vehicles are set up on the basis of tracked and wheeled vehicles with good cross-country performance (usually armored personnel carriers). Helicopters are being increasingly employed in foreign armies as a highly efficient means of communication and airborne command and staff vehicle.

In tank subunits up to and including the battalion, the task of ensuring reliable and continuous control is accomplished by employing radio equipment installed directly in the tanks.

Technical intelligence-gathering means and various information sensors are of importance for achieving continuous control.

An important role in staff operations is played by means of mechanizing information processing. First of all these include simple means of computation (keyboard calculators, tables, graphs, nomograms), means of speeding up map situation representation (various stamps, stencils, rulers), and means of mechanizing the preparation and duplication of documents.

Information processing means assist commanders and staff officers in rapidly synthesizing obtained situation data and in performing requisite calculations for decision-making and planning. According to information in the foreign press, employment of electronic computers makes it possible sharply to reduce the time required to perform calculations for employment of weapons, troop redisposition planning, and logistical support.

It is believed that sound recording equipment (tape recorders, dictation equipment) as well as photocopying equipment are among the most efficient means of situation display documenting. Operation orders and reports can be recorded with tape recorders and dictation equipment, and they can be rapidly disseminated by communication channels and in person. Thanks to this equipment, the quantity and volume of written combat documents is being sharply reduced. Various types of this equipment make it possible to duplicate documents quickly, which helps make troop control more effective.

Thus technical means substantially assist the commander and staff officers in exercising continuous and flexible troop control. They make it possible to handle only individual, particular questions, however. In this connection it is acknowledged abroad that under present-day conditions employment of means of automating control is essential. Today many items in the control activities of commanders and staffs should be settled and disseminated to executing personnel extremely quickly, within minutes and even seconds. This task can be accomplished only with the aid of sophisticated technical devices and automation of control processes.

Information in the foreign press states that electronic equipment of an automated troop control system makes it possible rapidly to obtain from subordinate and cooperating units and subunits, in which information sensors are placed, requisite situation data and to feed this data into an electronic computer at headquarters. After electronic computers have analyzed and synthesized received data, they produce the required information, calculations on the most important enemy targets, relative strengths, advisable axes of passage of contaminated zones, etc. On the basis of this information the commander will be able rapidly to make an optimal

decision and then communicate the mission to subordinates. All this will make it possible sharply to increase the effectiveness of utilization of new weapons.

At the same time, the availability of such means of control in tank troops not only does not reduce but on the contrary enhances the role of the commander and staff officer, for man alone can correctly utilize data obtained from machines.

Thus control of tank units and subunits in modern combat is a complex and multilevel productive process, which makes it possible to accomplish a large number of tasks in the shortest period of time, tasks which can be performed only by highly trained officers capable of working innovatively and efficiently.

SECTION VII. EMPLOYMENT OF MATHEMATICAL METHODS IN TANK TROOPS UTILIZATION DECISION-MAKING

Chapter 1. ESSENCE OF THE PROCESS OF DECISION-MAKING

A wealth of experience in employment of tank troops indicates that the process of decision-making and planning essentially constitutes purposeful processing of "state" information into "command" information. Information in the general definition (applicable to combat operations) is defined as any reports or data on the enemy, friendly troops, terrain, hydrometeorological conditions, events and facts which have occurred or will occur in the course of combat operations.

Information of "state" is defined as all information enabling one to establish the true state of all the above enumerated factors as of the time of situation estimate. "Command" information is defined as information on the tasks and objectives of troop actions, that is, commands, orders, and instructions which determine who is to do what and when.

In the process of purposeful processing of information there occurs selection of data required by the commander for decision-making and planning. Those principal factors which promote (or impede) accomplishment of the assigned task to the greatest degree are specified.

Processing of "state" into "command" information consists not only in selection of data but also in their analysis and determination of the role and significance of each factor in the course of solving the stated problem. A decisive role is played here by quantitative analysis. It has assumed fundamentally new significance under present-day conditions. A scientifically substantiated decision cannot be made without calculations and quantitative substantiation.

Forecasting of combat actions is performed, possible variants of actions are determined, and probable problem solution variants are specified in the process of information processing and calculation. The essence of the process of decision-making and planning with utilization of mathematical methods and electronic computers is as follows: on the basis of modeling forthcoming combat operations, the commander and his staff can predict possible variants of combat mission performance and select that decision with which the stated objective is optimally achieved.

Since man takes part in the process of decision-making and planning, this process has two aspects: objective, and subjective. The objective aspect includes the assigned combat mission, the enemy's intentions and actions, the composition of his forces, the character of the combat zone, armament, hydrometeorological conditions, terrain, time of year, time of day, etc.

The subjective aspect includes reflection of objective factors in the consciousness of the decision-maker and planner. Therefore one should consider that a decision is subjective, for it is made on the basis of representation of the objective in man's (the commander's) consciousness. This inaccurate, incomplete and partial representation of the developing situation, however, does not mean that correct decisions cannot be made. It is believed that a decision and plan in which the main features correctly reflect the situation and correspond to the assigned mission will be correct for all practical purposes. An incorrect decision is a decision which either is not in conformity with the assigned mission or which incorrectly reflects the main features of the developing situation. In order to make the right decision it is essential that the combat situation, the assigned mission and other factors which are independent of the will and consciousness of the commander be perceived as accurately as possible.

The adopted plan should contain elements of innovativeness. Innovativeness should be expressed in applying the principles of art of warfare proceeding from the laws of armed combat, and embodied in field manuals and regulations, not dogmatically but in conformity with the actual combat situation.

Alongside innovativeness, the commander should also display initiative in decision-making and planning. In this activity initiative is viewed as a response reaction to situation changes and newly appearing possibilities. It will be appropriate only if it is in agreement with the concept of the higher commander, corresponds to it and makes it possible optimally to implement this concept.

Many centuries of experience in waging war indicates that in the process of decision-making and planning commanders of all echelons should take into account and mandatorily utilize such factors as boldness, aggressiveness, and the ability to take a risk. Utilization of these factors of the art of warfare signifies nothing other than departure from unoriginal decisions and plans. Methods of action which are unexpected, unknown to the enemy, and contain the element of surprise provide additional chances for victory.

During decision-making and planning, the commander relies on the principles of the art of warfare, which are elaborated by theorists and practical experts in military affairs on the basis of cognition and revelation of the objective laws of warfare. Principles of the art of warfare, constituting the most general, fundamental and guideline ideas on methods of troop combat operations for achieving success in battle, provide commanders of all echelons with a general direction of action. The decision will be scientifically substantiated only if it is based on precise calculation and is in rigorous conformity with objective situation conditions and grounded on impartial analysis of the factors which influence the course of events. Mathematical methods of investigation displace various guesses, assumptions, and rough comparisons. K. Marx wrote that science will reach perfection only when it succeeds in utilizing mathematics.*

---

* See F. Lafarg, "Vospominaniya o Markse i Engel'se" [Recollections of Marx and Engels], Moscow, Gospolitizdat, 1956, page 56.

One must bear in mind here, however, that mathematical methods are only a device, a tool with the aid of which one can most fully take into account and utilize the objective laws and patterns of warfare.

Those areas of mathematics which have been developed in recent years for solving problems which lie beyond the boundaries of "classical" mathematics and are utilized for substantiation of decisions are encompassed by an area of scientific investigation called operations research. Operations research methods enable one to find optimal action variants on the basis of which a decision can be made. Thus operations research is primarily the mathematical edifice utilized in theory of decision-making.

Mathematical methods enable a commander to weigh advantages and disadvantages of each possible decision variant which, in combination with estimation of other factors not taken account in mathematical models, influence making a scientifically substantiated decision. A combination of logical (heuristic) and mathematical methods comprises the modern decision-making process.

Utilization of operations research methods, however, produces the greatest effect with utilization of electronic computers and automated troop control systems. This is due to the fact that in decision-making and planning under present-day conditions there arises the necessity of such rapid information processing that an electronic computer is essential. Therefore employment of means of automation, and particularly electronic computers, has become an integral element of the decision-making process.

Thus in today's definition the process of decision-making is a process connected with collection and processing of information on the enemy, friendly troops, their combat capabilities, the combat zone, hydrometeorological conditions, time of year and time of day on the basis of employment of computers for determining the most effective method of achieving the end objective of an engagement, combat actions, or operation.

It was noted above that mathematical methods are merely an instrument for making optimal (best) decisions. Therefore the results obtained with the aid of the edifice of operations research are evaluated by the commander. One employs such concrete forms of thinking as analysis and synthesis, induction and deduction, analogy, abstraction and concretization.

Analysis is a logical technique of breaking down a whole into its individual elements, with examination of each of these separately. Analysis is effective when it helps penetrate into the essence of the situation and determine in it the most important element, which influences the course and outcome of combat operations.

Analysis is inseparably linked with synthesis, that is, amalgamation of all data obtained as a result of analysis. "...Thinking," stated F. Engels, "consists as much in breaking down the objects of consciousness into their elements as in unifying related elements into some unity. There is no synthesis without analysis."*

* K. Marks and F. Engel's, "Soch." [Writings], Vol 20, page 41.

Synthesis makes it possible to reveal the essence of the process of waging combat, to establish cause-and-effect relations within that process, and to predict development of combat operations. When analyzing the combat situation and studying individual elements, one should immediately synthesize and establish the presence of links between these elements.

When estimating the situation, the commander should thoroughly penetrate it and endeavor to determine which of its elements are the main, essential elements, which are secondary, and what elements do not affect combat operations at all.

Analysis and synthesis closely interweave with induction and deduction. Induction is the movement of thought from the particular to the general, from a number of factors to a law. Deduction, on the contrary, is the movement of thought from the general to the particular, from a law to its individual manifestations.

The method of induction is inseparable from deduction, as analysis is inseparable from synthesis. While induction enables one to determine on the basis of individual facts which of the laws governing warfare is manifested under given conditions, deduction enables one to solve the inverse problem -- to determine in what any law can be manifested under given concrete conditions.

When analyzing the situation it is expedient to proceed sometimes from the particular to the general (induction), and at other times from the general to the particular (deduction), seeking to establish an interrelationship between situation phenomena and the laws of warfare.

Abstraction is employed when it is necessary to abstract from an entire set of factors and concentrate attention on any one item. Abstraction cannot produce a concrete solution, however, since it isolates a given fact (event) from the actual situation. Therefore alongside abstraction one should employ concretization -- tying in a given phenomenon with concrete situation conditions.

In the course of decision-making one can also employ analogy -- a technique in which from the similarity of two phenomena under identical conditions one concludes the similarity of these phenomena under other conditions as well. One must deal cautiously with analogies, however. An analogy is not proof, but merely ground for stating assumptions on the possible character of development of combat operations. One can obtain with the aid of analogy a first guess on the character of forthcoming actions, a guess which, following verification and utilization of other logical devices, can make it possible to foresee the development of events and consequently can make it possible to make a correct decision.

The key to knowledge of the laws governing and patterns of situation development and the course of combat operations is discovery of the cause-and-effect relations between situation elements and the course of combat operations. Causality is one of the general forms of objective relationship between objects, phenomena and processes of actuality. In order to make a correct decision, the commander and his staff officers must, in the process of decision-making and planning, discover and understand the cause-and-effect relationships in the events and phenomena of forthcoming combat operations.

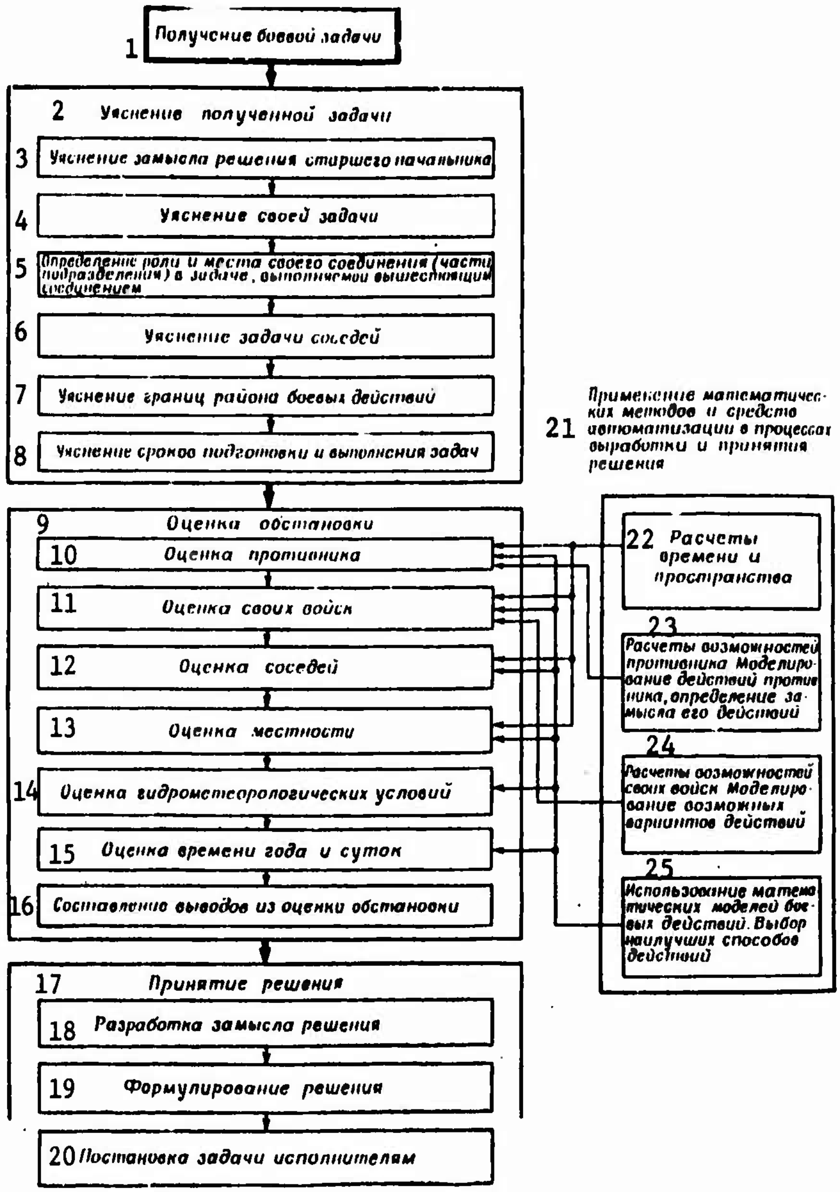


Figure 7.1.1. Process of Decision-Making

Key:

1. Receipt of combat mission
2. Clarification of received mission
3. Clarification of higher commander's decision concept
4. Clarification of one's mission
5. Determination of the role and place of one's combined unit (unit, subunit) in the mission performed by the higher combined unit
6. Clarification of mission of adjacent units
7. Clarification of boundaries of battle area
8. Clarification of timetable of preparation for and execution of missions
9. Situation estimate
10. Estimate of enemy

(Key to Figure 7.1.1 on preceding page, cont'd)

11. Estimate of friendly troops
12. Estimate of adjacent units
13. Estimate of terrain
14. Estimate of hydrometeorological conditions
15. Estimate of time of year and time of day
16. Comparison of conclusions from situation estimate
17. Decision-making and planning
18. Elaboration of general plan
19. Formulation of plan
20. Assignment of missions to executing entities
21. Employment of mathematical methods and means of automation in processes of decision-making and planning
22. Time and space calculations
23. Calculations of capabilities of enemy. Modeling of actions of enemy, determination of his general plan of action
24. Calculations of capabilities of friendly troops. Modeling of possible action variants
25. Utilization of mathematical models of combat operations. Selection of optimal modes of action

---

The process of decision-making and planning includes clarification of the assigned mission, situation estimate, elaboration of a general concept of the forthcoming combat operations, making and formulating the decision. In each element comprising the process of decision and planning, calculations can be performed both manually and with a computer, as well as modeling and analysis of results obtained in the course of calculations and modeling. Figure 7.1.1 contains a structural diagram of the process of decision-making and planning and utilization of electronic computers and modeling, according to foreign views. It is noted that several dozen problems have been prepared for commanders and staffs at the operational-tactical echelon in the U.S. Army, problems connected with securing accurate information on the combat situation, planning and conduct of combat operations.

Chapter 2. MATHEMATICAL METHODS PROVIDING ELABORATION OF OPTIMAL DECISIONS

The laws and patterns of warfare are extremely complex. They are based on quantitative relationships, which makes it possible successfully to apply mathematical methods. Mathematics proper, however, cannot be applied directly to a given combat action but only to a certain mathematical description of it, that is, a mathematical model. A model is a representation (abstraction) of an actual phenomenon, preserving its essential structure in such a manner that analysis of the model makes it possible to determine the influence of certain aspects of a phenomenon on other aspects or on the phenomenon as a whole.

The principal purpose of a model is to explain the laws and patterns of warfare for their subsequent utilization for purposes of control and substantiation of scientific forecasting. A fairly accurate model makes it possible to perform various experiments (studies) on the model as on the corresponding phenomenon. It is precisely this which dictates the necessity of modeling various combat operations, since performance of experiments on actual phenomena of a combat nature is impossible.

In relation to the logical properties and relationships of models with portrayed phenomena, they can be divided into two types: representational (models of geometric similarity), analog, and mathematical.

Representational (they are sometimes called physical) models reflect the external characteristics of phenomena and are similar to the original. They are simple and concrete. Such models in general are descriptive and do not provide capability to establish the causal relationship of phenomena and consequently to determine or predict the consequences of changes in the various parameters of phenomena. Such models may be representational models of tanks and other weapons, as well as sand boxes representing models of a battlefield or battle. Representational models represent the statics of a phenomenon but cannot reproduce its dynamics.

Analog models are models in which a set of certain properties is represented with the aid of a set of other properties. For example, terrain relief is represented on a map with the aid of contour lines. Any diagram is an analog model of some phenomenon. Such properties as time, number of combat units, cost, percentage of target destruction, etc are represented on diagrams by means of distances. Analog models include battle maps marked with the combat situation, with symbols indicating tactical or operational situation elements. Changes, that is, process dynamics, can be represented on an analog model by changing parameters at model input.

Another advantage of this model is its versatility: by slightly altering a model, one can show different variants of performance of missions of a single category. For example, by utilizing his battle map, which is an analog model of the combat operations of a given tactical entity, the commander, performing calculations, can quantitatively and qualitatively estimate different variants of performance of the assigned combat mission.

Mathematical (symbolic) models are models in which symbols of a mathematical character are used to represent the properties of the system being studied. Mathematical models are the most complex, the most general and abstract. They are used for investigating phenomena. With their aid one can determine and predict the consequences of changes in the parameters of a phenomenon under the influence of various factors. This signifies that by means of analysis of a model it is possible to select one mode of action which ensures attainment of the optimal result. Therefore such models are called optimization models.

Alongside modeling to find optimal solutions, various mathematical methods are employed, such as critical-path method and control method, linear and dynamic programming, games theory, queuing theory, probability theory, theory of optimal control, etc. In order to obtain optimal solutions it is essential to have effectiveness criteria, which will ensure selection of an optimal solution.

Chapter 3. CRITERIA OF EFFECTIVENESS

The indicator the numerical value of which is used to determine (estimate) the achieved result is called criterion effectiveness (optimum). It is essential in order to be able to select the best (optimal) solution by comparing the results of various solutions.

Since combat operations are of a diversified character and the most diversified means of combat participate in them, there can be no single criterion which is suitable for all cases of combat operations. It is more correct to speak of a system of criteria of effectiveness (optimum).

Criteria of effectiveness should satisfy the following conditions: reflect the objective of combat operations; be critical (sensitive) to changes in those quantities the significance of which is determined in the course of investigation; be simple, so that their physical sense can be understood and it is convenient to compute, graphically represent and analyze them.

A correctly selected criterion of effectiveness should objectively reflect the essence of the influence of principal factors on the course and outcome of combat operations. An effectiveness criterion is determined by the assigned combat mission, and therefore selection of a criterion of effect'veness depends on clarification of the combat mission and the ability to elucidate the most important operation outcome indicators. A criterion of effectiveness (optimum) should precisely indicate the degree to which the end result of combat operations changes with a change in various situation conditions, that is, with a change in controlled and uncontrolled variables.

The principal types of criteria of effectiveness are probability of accomplishment of combat mission and mathematical expectation of damage inflicted on the enemy.

If, for example, the assigned combat mission is designated by event A, the probability of occurrence of event A will be the criterion of effectiveness:

$$W=P(A), \tag{7.1.1}$$

where W -- criterion of effectiveness; P(A) -- probability of event A.

Criteria of effectiveness are subdivided into general and particular. The former characterize effectiveness as a whole, and the latter -- its individual component

parts. In concrete problems one employs criteria which as a rule are a concretization or combination of two principal methods (kinds) of criteria -- probability and mathematical expectation.

If combat operations are undertaken to achieve a specific result which may or may not be achieved, in an offensive action, for example, the criterion of effectiveness may be the probability of accomplishment of the assigned mission or mathematical expectation of damage inflicted on the enemy. In defensive operations the probability of survival of friendly targets or the mathematical expectation of the number of undestroyed friendly units can be employed as criterion of effectiveness.

Probability of scoring hits on enemy targets (positions, command posts, aircraft, warships, etc) can be criteria in accomplishment of combat missions.

If combat operations are undertaken to ensure maximum possible value of any quantity or its minimum value, the mathematical expectation of this quantity can serve as a natural criterion of effectiveness.

Criteria of effectiveness can be subdivided according to results of actions:

by achieved results -- mathematical expectation of damage inflicted on the enemy, or probability of accomplishment of a combat mission; it is applied when the principle of reasonable economy of friendly forces has a subordinate value in respect to the operation objective;

by expenditures -- mathematical expectation of damage inflicted on friendly forces; it is applied when reduction in expenditure of one's own forces, reduction in friendly casualties, or savings in resources is of special significance;

by relative results -- mathematical expectation of damage per unit of expenditures or as average expenditures per unit of damage inflicted on the enemy;

by relative effectiveness employed to estimate various forces and equipment in carrying out either one and the same mission or different missions by one and the same forces.

Criteria can be subdivided by the character and scale of the target operation into strategic, operational, tactical, fire, operational and combat support, as well as military-economic, characterizing the effectiveness of rear services, industrial, transportation, economic and other analogous problems.

In conclusion we must note that in determining criterion of effectiveness one should proceed from the essence of an operation, common sense and that realistic objective which the commander (commanding general) pursues. If, for example, the task consists in determining a more advantageous grouping of combat means in comparison with the existing grouping, it is appropriate to adopt as criterion of effectiveness the ratio of the result achieved with the new grouping to the result which was achieved with the existing force grouping. The results proper are evaluated by probability or mathematical expectation.

Frequently one employs as criterion of estimate of forthcoming combat operations the ratio of losses of the opposing sides (mathematical expectation of losses) or relative strengths of the opposing sides, which is usually computed prior to the initiation of combat operations and change in which is of interest to the command in the course of combat operations.

Sometimes such a criterion as the ratio of expended means to achieved results, for example, proves to be very useful. The ability to determine the measure of general effectiveness becomes important thereby.

In investigating queuing systems, additional criteria of effectiveness include probability of service failure, mathematical expectation of number of occupied servicing units, length of servicing queue, servicing initiation waiting time, time expended by each means on servicing, etc.

Not one but two or more criteria can be selected in decision-making and planning. In this instance an effort is made to unify all criteria into a synthesized criterion, or one of the criteria, which corresponds to the stated objective to the greatest degree is considered the main criterion, while the others are considered auxiliary criteria. The numerical value of auxiliary criteria should be improved only within certain limits, within the boundaries of which this will not exert negative influence on the value of the main criterion.

Since headquarters staffs of different echelons in the different services may be solving calculation problems of a single type, for uniformity it is expedient to employ identical effectiveness criteria as well. Then it will be possible to compare and synthesize the solution results of problems of the same type.

Proceeding from the level of training of executing personnel, the degree to which control agencies are equipped with computer hardware, as well as the selected criterion of effectiveness and character of the target operations, various mathematical methods are employed, from the simplest analysis to simulation with the employment of complex mathematical relationships based on input data characterizing the concrete prevailing situation.

Chapter 4. PRACTICAL APPLICATION OF MATHEMATICAL METHODS AND MODELS

This article contains practical recommendations on application of mathematical methods with generalized operational-tactical examples of the past war or arbitrarily taken examples. We shall call the opposing forces "Red" and "Blue," as is the practice in foreign publications.

1. Application of Methods of Classical Mathematics

Example 1. Figure 7.4.1 shows the position of the opposing forces, which is known to the commander of the "Red" force during seizure of the mountain pass by its forward units. This situation was placed on the map by the commander of the "Red" force, who is positioned at the head of the main force column. In addition, the following is known to the commander: forward units of the "Red" force are successfully repelling assaults by forward units of the "Blue" force. The "Blue" main forces can reach their forward units in 11-11.5 hours, counting time for crossing the Vadul River (the bridge has been destroyed by "Red" force aircraft), at which time the situation of the forward units of the "Red" force will become very critical.

The commander of the "Red" force has the following task: taking account of the actual situation (enemy forces, position of friendly forces, terrain conditions and character), find an optimal route of advance which ensures that the main forces reach the forward unit in a prompt and timely manner, in not more than 11 hours.

Solution. 1. The commander performs an additional plot on the map (see Figure 7.4.1).

2. He determines initial data from the map: route segment $AE=h_1=18$ km; segment $EД=h_2=27$ km; segment $ДB=l=85$ km.

Maximum respective average rates of advance, taking actual conditions into account, can be the following: on segment $AE=v_1=6$ km/h; on segment $EД=v_2=9$ km/h; by road, on segment $ДB=v_3=15$ km/h.

Changing variables: $ДД_1=x$, $Д_1C=y$ or angles θ_1 and θ_2.

3. The time at which the main forces of the "Red" force reach the covering force, $t \leqslant 11$ hours, is adopted as criterion of effectiveness. The route of movement is the dashed line.

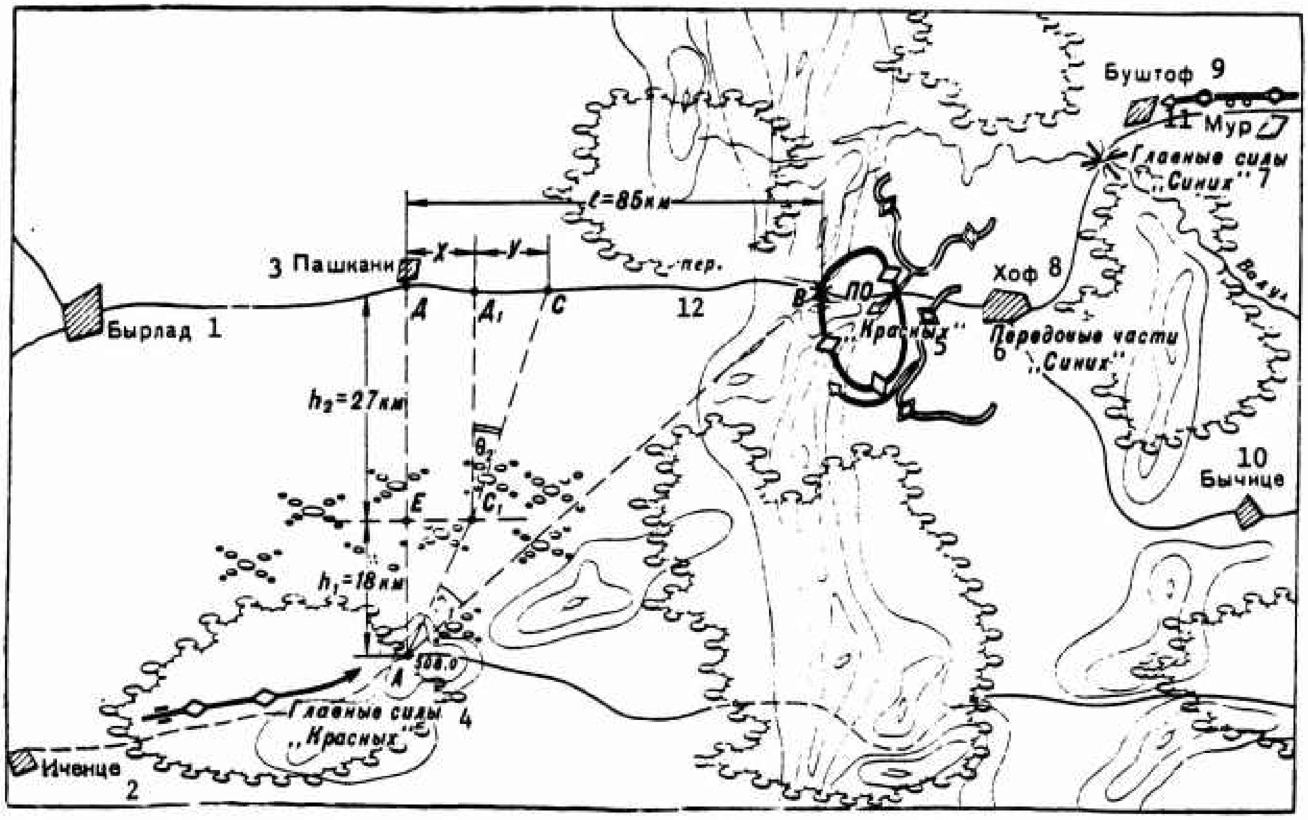


Figure 7.4.1. Position of Opposing Forces During Seizure of Pass by Forward Units of "Red" Force (based on an example of synthesized experience of the past war)

Key:

1.	Byrlad	7.	Main forces of "Blue" force
2.	Ichentse	8.	Khof
3.	Pashkani	9.	Bushtof
4.	Main forces of "Red" force	10.	Bychitse
5.	Covering force of "Red" force	11.	Mur
6.	Forward units of "Blue" force	12.	Pass

4. Criterion of effectiveness t is expressed via other quantities:

$$t = \frac{AC_1}{v_1} + \frac{C_1C}{v_2} + \frac{CB}{v_3}. \qquad (7.4.1)$$

From $\triangle AEC_1$ we find $AC_1 = \sqrt{h_1^2 + x^2}$; from $\triangle C_1D_1C$ we find $C_1C = \sqrt{h_2^2 + y^2}$; $CB = l - x - y$.

Then

$$t = \frac{\sqrt{h_1^2 + x^2}}{v_1} + \frac{\sqrt{h_2^2 + y^2}}{v_2} + \frac{l - x - y}{v_3}. \qquad (7.4.2)$$

Substituting values of parameters, we obtain

$$t = \frac{\sqrt{324 + x^2}}{6} + \frac{\sqrt{729 + y^2}}{9} + \frac{85 - x - y}{15}. \qquad (7.4.3)$$

5. We find the values of variable quantities (x and y), whereby criterion of effectiveness t becomes minimum. For this we compute partial derivatives from t by x and y and equate to zero:

$$\frac{\partial t}{\partial x} = \frac{x}{6\sqrt{324 + x^2}} - \frac{1}{15} = 0; \qquad (7.4.4)$$

$$\frac{\partial t}{\partial y} = \frac{y}{9\sqrt{729 + y^2}} - \frac{1}{15} = 0. \qquad (7.4.5)$$

6. We simplify and solve these equations:

$$189\, x^2 = 324 \cdot 36;$$
$$144\, y^2 = 729 \cdot 81,$$

whence x=8 km; y=20 km; θ_1=23°45'; θ_2=36°30'.

7. We determine the minimum time required for the main forces to advance to the covering force:

$$t = \frac{\sqrt{324 + 8^2}}{6} + \frac{\sqrt{729 + 20^2}}{9} - \frac{85 - 8 - 20}{15} = \text{10 hours 40 minutes} \qquad (7.4.6)$$

Thus movement should follow the route AC_1, C_1C, CB, and point C_1 should be positioned 28 km from point Д. In this case the main forces of the "Red" force will reach Gotard pass ahead of the main forces of the "Blue" force, and the mission assigned to the "Red" force will be accomplished.

Example 2. The covering force of the "Red" force, operating at the enemy's operational depth and moving along a single road, reached the village of Demby with the head of its column (Figure 7.4.2), with the mission of capturing a position running on a line from Hill 180.0 to Hill 175.0 and supporting deployment of the main forces of the "Red" force directly from march formation for an attack in the direction of Bobovichi-Kraty.

The enemy's forward units, advancing from Prutki, may concentrate the main forces east of Lugan' and attempt an attack in the direction Lugan'-Hill 160.0 (1 km north of Petrovka), in order to take up a flank position in respect to the "Red" main forces.

Estimating the situation, the commander of the "Red" covering force reached the conclusion that he can smash the enemy's forward units only under the condition of a simultaneous frontal attack by tanks of the 1st Battalion and a flank attack from the south by the 2d Battalion in the direction Hill 172.5-Lugan'.

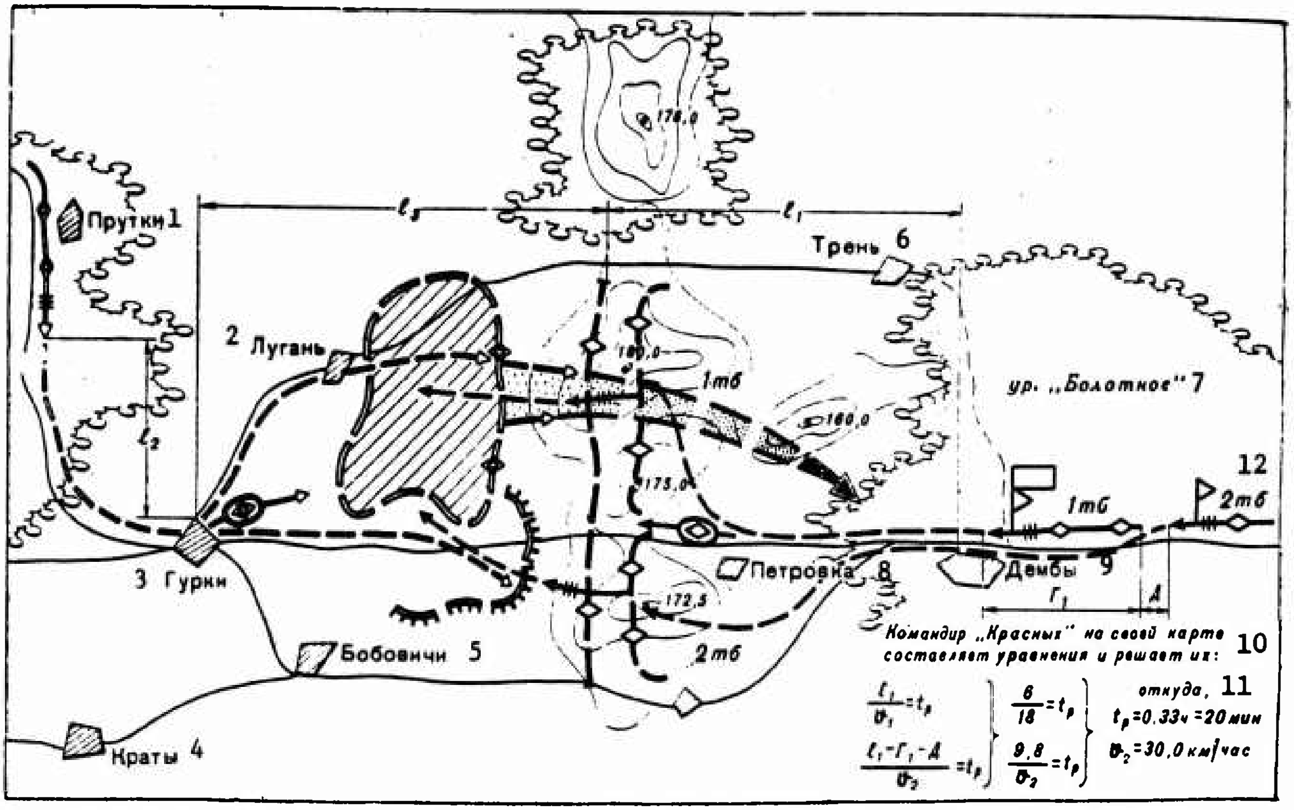


Figure 7.4.2. Position of Opposing Forces and Example of Employment of Classical Mathematics for Solving a Tactical Problem (based on synthesized experience of the past war)

Key:

1. Prutki	7. "Bolotnoye" natural landmark
2. Lugan'	8. Petrovka
3. Gurki	9. Demby
4. Kraty	10. Commander of "Red" force constructs equations on his map and solves them:
5. Bobovichi	11. Whence... km/h
6. Tren'	12. Tank battalion

It is necessary to determine the time of simultaneous deployment of both battalions and the rate of advance and deployment of the 2d Tank Battalion, if the average rate of advance and deployment of the 1st Tank Battalion, proceeding from terrain conditions, is v_1=18 km/h; distance between the deployment line and the column head is l_1=6 km; column length of the 1st Tank Battalion is $Г_1$=1.8 km, and the column gap between the 1st Tank Battalion and 2d Tank Battalion is Д=2 km. The enemy may deploy in 30 minutes. The position of the opposing forces and possible actions by the "Blue" force are shown in Figure 7.4.2.

Solution. 1. We shall adopt as criterion of the optimum deployment time t_p and requisite rate of advance of the 2d Tank Battalion v_2, ensuring simultaneous deployment and engagement of both battalions.

2. The commander of the "Red" covering force constructs and solves the equations on his battle map by means of additional plots (see Figure 7.4.2). He proceeds from the position that simultaneous battalion deployment time t_p, rate of advance and deployment of the first v_1 and second v_2 battalions, distance to deployment line l_1, as well as column length of the 1st Tank Battalion $Г_1$ and the column gap between the first and second battalions Д are linked by the following relations:

$$\left.\begin{aligned} \frac{l_1}{v_1} &= t_p; \\ \frac{l_1 + Г_1 + Д}{v_2} &= t_p. \end{aligned}\right\} \qquad (7.4.7)$$

This means that both battalions will reach the deployment line and engage simultaneously.

Substituting input data in system (7.4.7), we determine the required quantities:

$$\left.\begin{aligned} \frac{6}{18} &= t_p; \\ \frac{9.8}{v_2} &= t_p. \end{aligned}\right\} \qquad (7.4.8)$$

Hence t_p=0.33 hours=20 minutes; $v_2 \simeq 30.0$ km/h. Since deployment time of the "Blue" force is $t_{p.c}$=30 minutes, while deployment time of the "Red" force is $t_{p.k}$= 20 minutes, time $t_{p.k}$ satisfies the conditions.

Thus the covering force should reach the deployment line in 20 minutes, while the 2d Tank Battalion should advance toward the line at a rate of not less than 30.0 km/h.

Example 3. A tank column consisting of two subunits deploys into a line of columns (Figure 7.4.3). The length of the lead subunit column is $Г_1$=1.8 km, and the column gap is Д=2 km. Determine deployment time t_p and speed of the lead subunit v_1 if the distance between deployment lines is l_p=4.5 km, and maximum speed of the second subunit is v_2=25 km/h.

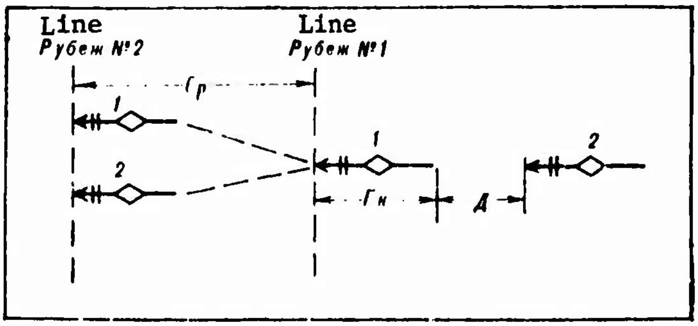


Figure 7.4.3. Diagram of Deployment of Tank Column (variant)

Solution. Quantities t_p, v_1, v_2, l_p, $Г_1$, and Д are interlinked by two obvious equations:

$$\frac{l_p}{v_1} = t_p;$$

$$\frac{l_p + Г_1 + Д}{v_2} = t_p,$$

which signify that both subunits should reach the second line simultaneously (Figure 7.4.3).

In order to utilize the latter expression for calculations, it is necessary to assign specific values to four of the six quantities, and to find the two remaining values from the two equations. The required quantities t_p and v_1 are determined for the conditions of our problem:

$$\frac{4.5}{v_1} = t_p;$$

$$\frac{8.3}{25} = t_p.$$

From this we find: t_p=0.33 hours=20 minutes, v_1=13.6 km/h. On the basis of the obtained results, the commander issues appropriate commands for deployment of the subunits taking the performed calculations into account.

Example 4. Determine the time required for moving across a river N=48 tanks on six units of self-propelled crossing equipment of two types: four of the first type and two of the second, across a river L_p=450 meters wide. Current velocity is v_p= 3.6 mps; speeds of crossing equipment in still water are v_1=9 km/h and v_2=6 km/h respectively. Time to load and unload a tank is t_1=7 min for equipment of the first type, and t_2=10 min for the second type.

Solution. In order to determine the required quantity, it is necessary to determine the duration of a vehicle-crossing for each of the types of crossing equipment, with the formula

$$T = \frac{2L_p}{v}(1+K)+t,$$

where v -- speed of crossing equipment; t -- loading and off-loading time; K -- correction for current velocity.

When $v_p > 2$ mps, K is assumed equal to one third of the current velocity in meters per second.

$$T_1 = \frac{2\times 450}{150}(1+1.2)+7=20 \quad \text{min;}$$

$$T_2 = \frac{2\times 450}{100}(1+1.2)+10=30 \quad \text{min.}$$

To determine crossing time T=x, one must construct the following equation:

$$\frac{n_1}{T_1}x + \frac{n_2}{T_2}x = N,$$

where n_1, n_2 -- number of units of crossing equipment of the first and second types; N -- number of tanks to be ferried across.

Substituting concrete values in the last equation, we obtain

$$\frac{4}{20}x+\frac{2}{30}x=48.$$

Solving the last equation, we obtain T=x=180 min=3 hours.

Thus, if we figure only for available crossing equipment, tanks will be able to be across the river no sooner than in 3 hours. Additional capabilities must be found in order to shorten this time.

2. Application of Probability Theory

Example 5. The 2d Tank Battalion has driven forward and reached intermediate defensive line Zakemp'ye-Hill 190.4-Lesnaya, where they were counterattacked by superior enemy forces. At the same time the battalion commander, positioned on Hill 187.5, spotted an enemy tactical missile launcher taking up position at the edge of the woods northwest of Lesnaya (Figure 7.4.4).

The battalion commander has two important missions: destroy the enemy launcher and repel the counterattack by superior enemy forces.

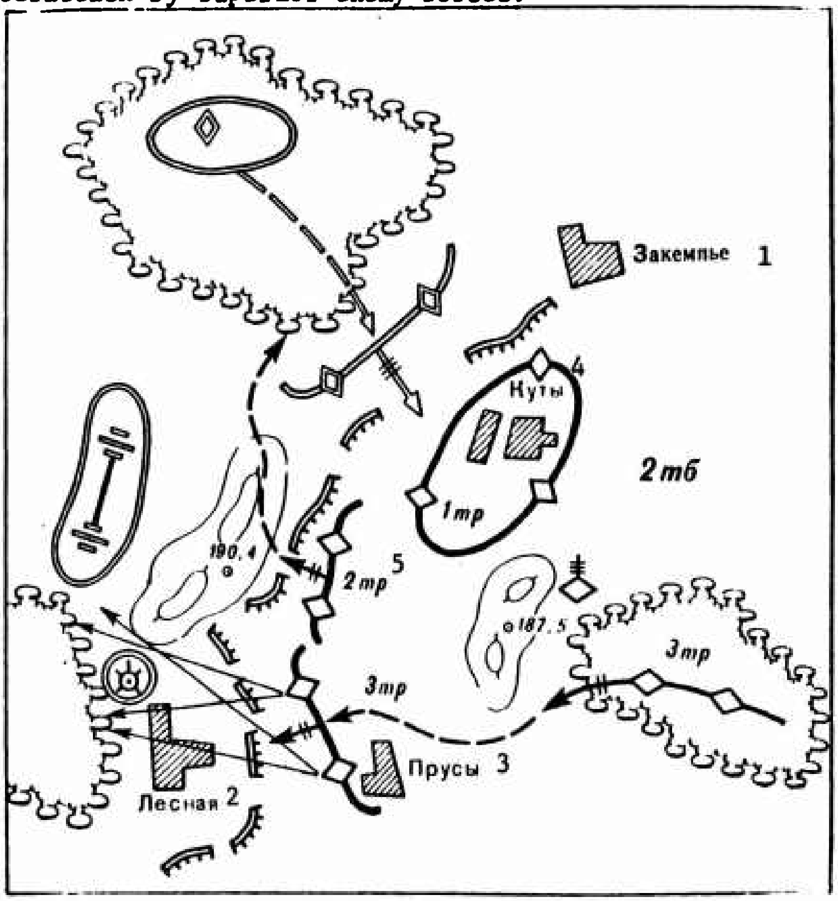


Figure 7.4.4. Position of Opposing Forces on Line Zakemp'ye-Hill 190.4-Lesnaya

Key to Figure 7.4.4 on preceding page:

1. Zakemp'ye
2. Lesnaya
3. Prusy
4. Kuty
5. Tank company

We must determine the required number of tanks for destroying the deploying enemy missile launcher with the first rounds fired, with a high degree of reliability $\beta=0.97$ (97 percent).

Solution. It is expedient to adopt probability of scoring an effective hit on the enemy missile launcher p_n as criterion of effectiveness. The commander's decision is determined by quantity x -- the number of tanks assigned to destroy the launcher.

We shall determine firing conditions by the probability of hitting the target with the first round fired by one tank. We shall assume that under the given conditions this quantity will be identical for all tanks and equal to 0.45. This quantity (p) depends on range of fire, projectile characteristics, and degree of protection of the enemy target. It is computed on the basis of appropriate range tables and formulas.

The relationship between p_n, p, x is determined by the well-known formula

$$p_n=1-(1-p)^x. \quad (7.4.9)$$

The inverse problem is solved in this example, since $p_n=\beta=0.97$ and is known from the condition. We must find the value of controlled quantity x. This quantity is determined by exponential equation

$$0.97=1-(1-0.45)^x=1-0.55^x. \quad (7.4.10)$$

Solving this equation, we obtain

$$x=\frac{\lg 0{,}03}{\lg 0{,}55}=\frac{1{,}5229}{0{,}2596}=5{,}87. \quad (7.4.11)$$

Rounding off the value of x, we obtain 6.

Thus the following will be the optimal decision of the commander of the 2d Tank Battalion: to detail six tanks from the 3d Tank Company to destroy the enemy missile launcher, employing his remaining forces to repel the enemy tank counterattack.

Example 6. A tank crew spotted an enemy tank during combat. The tank commander ordered the target to be destroyed with three rounds fired by the tank gun. Estimate the tank's capabilities to destroy the enemy tank with three rounds.

Solution. It is expedient to adopt target kill probability p_n as criterion of effectiveness. The tank commander's decision variant is a target kill with three rounds. Firing conditions are determined by the values of hit probabilities p_1, p_2, p_3 respectively on the first, second and third rounds and the average number of hits ω requisite for a target kill. Quantities p_1, p_2, p_3 depend on range to

target and a number of other factors and are determined from corresponding tables, while number ω is known from experience. Let these quantities be already computed:

$$p_1=0.60;\ p_2=0.75 \text{ and } p_3=0.85;\ \text{while } \omega=1.2.$$

Dependence of p_n on p_1, p_2, p_3 and ω is established by the well-known probability theory formula

$$p_n=1-\left(1-\frac{p_1}{\omega}\right)\left(1-\frac{p_2}{\omega}\right)\left(1-\frac{p_3}{\omega}\right).$$

Substituting concrete values in this formula and performing computations, we obtain

$$p_n=1-\left(1-\frac{0{,}60}{1{,}2}\right)\left(1-\frac{0{,}75}{1{,}2}\right)\left(1-\frac{0{,}85}{1{,}2}\right)=$$
$$=1-0{,}5\times0{,}38\times0{,}29=0{,}95.$$

A fairly large value for the criterion of effectiveness of the performed mission corresponds to the tank commander's decision. The enemy tank will be destroyed with practical certainty. The tank commander's decision is well substantiated.

3. Application of Linear Programming Method

Example 7. In the zone of advance of tanks, ten targets of three types, of an equal degree of importance, must be destroyed: five of the first type, two of the second type, and three of the third type. Four weapons of each of two powers are assigned to this mission. Probabilities of killing targets of each type by any type of weapo are computed and presented in Table 7.4.1.

Table 7.4.1. Probability of Target Kill

Типы средств поражения (1)	Тип поражаемой цели (2)			Количество средств поражения (3)
	1	2	3	
1	0,3	0,6	0,8	4
2	0,7	0,8	0,4	4
(4) Количество целей	5	2	3	8 / 10

Key:
1. Weapon type
2. Target type
3. Number of weapons
4. Number of targets

It is necessary to distribute weapons among targets in such a manner that, taking a maximum number of targets under fire, the effect of weapon utilization will be maximum.

Solution. In this problem it is expedient to select the mathematical expectation of number of destroyed enemy targets W as criterion of effectiveness. We shall designate with x_{ij} the number of weapons of type i assigned to targets of type j: i=1, 2; j=1, 2, 3. There will be a total of 2 x 3=6 of such quantities; they will obviously determine variants of distribution of weapons among targets (controlled quantities). Quantities determining the conditions of the problem are contained in Table 7.4.1.

The value of mathematical expectation W by x_{ij} is expressed by a formula known from probability theory:

$$W = 0{,}3x_{11} + 0{,}6x_{12} + 0{,}8x_{13} + 0{,}7x_{21} + 0{,}8x_{22} + 0{,}4x_{23}. \qquad (7.4.12)$$

In addition, expressions linking values x_{ij} are obtained from the conditions of the problem:

$$\left.\begin{aligned} x_{11} + x_{12} + x_{13} &= 4; \\ x_{21} + x_{22} + x_{23} &= 4; \\ x_{11} + x_{21} &\leqslant 5; \\ x_{12} + x_{21} &\leqslant 2; \\ x_{13} + x_{23} &\leqslant 3, \end{aligned}\right\}, \qquad (7.4.13)$$

where the first two equations determine the number of weapons of both types (4 each), and the last three inequalities -- the number of targets by types (5, 2, and 3). For solving the problem it is necessary to find nonnegative integers x_{ij} (i=1, 2; j=1, 2, 3), which satisfy linear expressions, whereby expression (7.4.12) will assume a maximum value.

A modern mathematical method which has been given the designation linear programming method, can be used to solve problems similar to the formulated problem. This method, complex in a computational respect, is efficiently realized with the aid of a computer.

The example under consideration is easily solved without resorting to general linear programing methods. Focusing on the greatest kill probabilities, one can demonstrate that the optimal solution will be $x_{11}=1$; $x_{12}=0$; $x_{13}=3$; $x_{21}=2$; $x_{22}=2$ and $x_{23}=0$ (killing one target of the first type and three targets of the third type with weapons of the first type, and two targets of the first type and two targets of the second type with weapons of the second type).

Maximum average enemy losses will occur with the first target allocation variant:

$$W_{max} = 1 \cdot 0{,}3 + 3 \cdot 0{,}8 + 2 \cdot 0{,}7 + 2 \cdot 0{,}8 = 5{,}7 \simeq 6 \qquad \text{targets.}$$

Following will be an infelicitous plan: $x'_{11}=4$; $x'_{12}=x'_{13}=0$; $x_{21}=1$; $x'_{22}=0$; $x'_{23}=3$, whereby losses will equal $W=4\cdot0.3+1\cdot0.7+3\cdot0.4=3.1=3$ targets.

Consequently, an infelicitous plan of distribution of weapons among targets can diminish their effectiveness quite significantly (almost twofold in our example).

If it is decided to assign several weapons to targets, problem solution becomes more complicated: a more complex nonlinear expression is formulated in place of linear expression (7.4.12). In this case the problem is solved by the linear programming method.

Optimal solution variants in more complex problems are obtained by dynamic programming methods.

Naturally employment of mathematical methods, especially modern methods, involves considerable expenditures of time, which headquarters staffs always find insufficient. Therefore in order to reduce time expenditures, standard calculation methods and mathematical models are elaborated in advance, as well as methods of their implementation.

Calculations are performed on the basis of fairly simple methods and models for a larger number of variants and input data. Compact tables are formulated on the basis of the obtained results, graphs, nomograms, and slide rules are constructed, utilization of which provides considerable savings of time and manpower on performing calculations. In addition, this frees staff officers from the necessity of studying and remembering the fine points of calculation methods and mathematical models.

Complex calculation methods and mathematical models are realized with the aid of computer hardware (electronic computers, SKM [expansion unknown]), for which computer programs and computation blanks for SKM are prepared in advance.

When computer programs are available, the officer's principal concern in performing calculations is preparation of input data and feeding this data into the computer, which will generate results in a form convenient for utilization. When employing an SKM, input data must be entered in the appropriate columns (lines) on the blank and one must perform the mathematical operations indicated in the other columns.

When staff officers are sufficiently well practiced, high-quality calculations can be performed in a short period of time utilizing tables, graphs, nomograms, slide rules and computer hardware, for the benefit of commander and staff.

4. Fundamentals of Mathematical Modeling of Tank Combat Operations

Cognition of reality is accomplished by means of direct study of phenomena (processes, objects) or their analogs (copies, images), which are called models. Study of phenomena with the aid of their models is called modeling [or: simulation].

The structure of the model of a process corresponds to the structure of the original; the model substitutes for the actual process in a cognitive or practical respect. Modeling enables one to obtain new information on phenomena which is difficult or impossible to obtain by other methods. Nonexistent processes (objects) are successfully studied by means of modeling, and it helps develop optimal plans for their creation.

Modeling possesses particular significance in military affairs. This is due to the fact that actual combat operations occur only during war. Preparation for combat operations is accomplished with the extensive employment of modeling.

Physical, mathematical and combined models possess the greatest practical significance (Figure 7.4.5). Field exercises, maneuvers, as well as proving-ground testing of weapons and combat equipment are examples of physical models. Examples of combination models include command and staff exercises, where staff operations are modeled physically, while troop actions are reproduced conventionally (on maps, in documents).

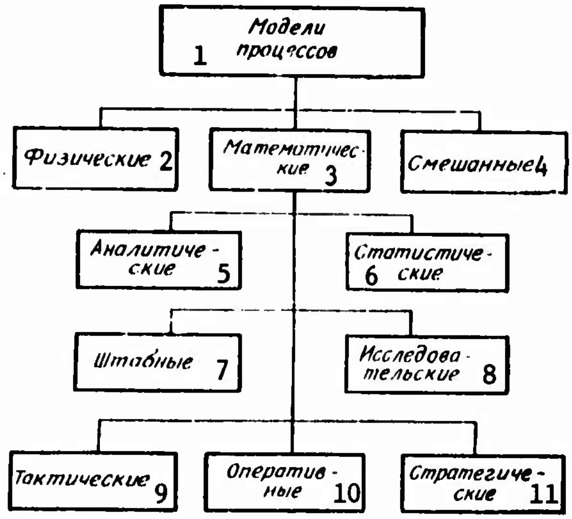


Figure 7.4.5. Classification of Models

Key:

1. Models of processes
2. Physical
3. Mathematical
4. Combination
5. Analytical
6. Statistical
7. Staff
8. Research
9. Tactical
10. Operational
11. Strategic

Physical and other types of models possess a number of significant drawbacks which complicate and limit their utilization (difficulties of reproducing actual conditions, large expenditures of manpower, resources, time, etc).

As a consequence of this, mathematical models began to be extensively used for studying troop combat operations and troop support, as well as for developing new weapons, combat equipment and methods of their employment.

Mathematical model of combat operations is defined as a set of mathematical and logical relationships which describe them with the requisite completeness and accuracy.

Study of actual combat operations or their physical models is replaced by investigation of mathematical and logical expressions and performance of appropriate calculations.

Mathematical and logical expressions which comprise a mathematical model, expressing quantitatively the course of combat operations, establish relationships between input data and a number of sought synthesized quantities (criteria).

Adopted as input data are quantities, some of which express a solution variant, while others express situation conditions (performance characteristics of weapons and combat equipment, initial status of the opposing forces, quantity of men and equipment, weather, etc). The results of combat operations are unknown quantities: probability of victory over the enemy, enemy and friendly casualties and losses by any specified time, position of the opposing forces, etc.

Specifying certain values to input data (solution variant and situation conditions), one obtains by means of simulation synthesized quantitative results of combat operations.

Thus one can play out in advance, on an electronic computer, for example, forthcoming combat operations on a repeated basis, and one can utilize the obtained results in decision-making and planning.

Quantitative indices obtained as a result of mathematical modeling enable one to reach conclusions:

on the combat capabilities of friendly and enemy forces;

on the composition of forces, weapons and support requisite for accomplishing and supporting execution of assigned combat missions;

on different variants of possible decisions and plans for the purpose of selecting optimal ones;

on the possible course and outcome of a planned engagement (operation);

on the content of missions assigned to subordinate units (subunits), etc.

Mathematical models make it possible to alter the conditions and possible solutions within a broad range and repeatedly to play out combat operations even prior to assigning missions and conduct of combat operations. Therefore mathematical modeling is an important modern method which substantially facilitates scientific foresight, adoption of well-substantiated decisions, and elaboration of optimal plans of combat operations and support.

Mathematical models are created on the basis of accepted points of military science, and consequently the results of modeling constitute a test of these theses. Therefore mathematical modeling is an important instrument for development of military science.

Mathematical modeling is conditionally formed of two principal stages:

determination of input data and sought quantities and construction of logical-mathematical expressions which describe in an approximate manner the course of combat operations;

utilization of obtained mathematical and logical expressions by means of their investigation and performance calculations.

The most diversified mathematical methods are employed in formulating mathematical and logical expressions which describe in approximate fashion the course of combat operations. In view of the complexity of the processes of combined-arms combat, they can be described mathematically in the general case with the aid of a number of fairly complex methods, both classical and modern.

Naturally all factors influencing the course of combat operations cannot be taken into account when constructing a mathematical model. Factors of substantial significance are taken into account, while secondary factors are discarded. Selection and consideration of important factors are accomplished by means of comprehensive analysis of the target process, with utilization of the experience of combat operations, exercises and the results of previous modeling, if the latter has occurred. Considered factors are refined during construction of a model. Final conclusions on whether all important factors have been considered are made by comparing the results of simulations with the results of combat operations and exercises which are close to the conditions considered in the model.

The volume of calculations in mathematical modeling is so large that it is practically impossible to perform them in a short period of time without utilization of modern electronic computers.

Two principal types of mathematical models are distinguished: analytical, and statistical (Figure 7.4.5).

In analytical models the sought quantities, qhich determine the course and outcome of combat operations, are expressed via input data with the aid of formula expressions. These models are convenient in a practical respect. But it is not always a simple matter to repeat such models; they often fail to provide adequate accuracy and proper consideration of the operation of random factors.

In statistical models each random factor is played out, and then its concrete significance to occurrence of the process is taken into account. The values of sought quantities prove to be random. In order to investigate a process with the aid of such a model, it must be played out repeatedly, and statistical data must be obtained on it. Processing of statistical data obtained with the aid of a model by the methods of mathematical statistics produces quantitative indices of the course of the process being studied.

Statistical models are simple to construct but complicated to utilize. As a rule they are realized on electronic computers containing random-number generators. These are devices which produce random numbers which are uniformly distributed in the interval (0, 1). Using a random-number generator, one can play out (simulate) a large number of various random factors. Statistical data on the course and outcome of processes obtained with the aid of such models are processed on a computer.

Mathematical models are subdivided according to purpose into staff and research, and into tactical, operational, and strategic on the basis of scale of reproduced combat operations. We shall examine examples of simple mathematical models.

Simple Models of A Tank Subunit Fire Fight

Analytical Model

Adversaries I and II are examined on an equal basis. Let the subunit of adversary I contain N_1 identical tanks, and the subunit of adversary II -- N_2, also identical, tanks. Rates of fire and enemy tank kill probabilities with one round are equal to λ_1, p_1 and λ_2, p_2. Quantities $\Lambda_1=\lambda_1 p_1$ and $\Lambda_2=\lambda_2 p_2$, called effective rates of fire, determine the quality of the adversary's tanks. They depend on range of fire, performance characteristics of guns and ammunition, tank armor protection, crew training, etc.

We shall determine the course of subunit combat by the average number of surviving tanks $n_1(t)$ and $n_2(t)$ respectively at any moment t from initiation of combat ($t=0$ corresponds to commencement of combat). Knowing n_1 and n_2, at any moment in time one can determine average losses as a function of time:

$$r_1(t)=N_1-n_1(t);\ r_2(t)=N_2-n_2(t).$$

Obviously quantities n_1 and n_2 will depend on the number of tanks N_1 and N_2 in the adversary's subunits at the commencement of battle and their quality, determined by quantities Λ_1 and Λ_2 respectively.

With a number of assumptions, in order to determine n_1 and n_2 it is necessary to solve a system of two differential equations:

$$\left.\begin{aligned} \frac{dn_1}{dt} &= -n_2\Lambda_2; \\ \frac{dn_2}{dt} &= -n_1\Lambda_1. \end{aligned}\right\} \qquad (7.4.14)$$

Initial conditions: $t=0$, $n_1=N_1$, $n_2=N_2$.

Equations (7.4.14) constitute a mathematical model of a fire fight between tank subunits, with a number of assumptions made when deriving these equations.

With different values of N_1, N_2, Λ_1, Λ_2, there will be different variants of combat, and, consequently, different dependences of n_1 and n_2 on t. Figure 7.4.6 shows one possible variant of change of n_1 and n_2.

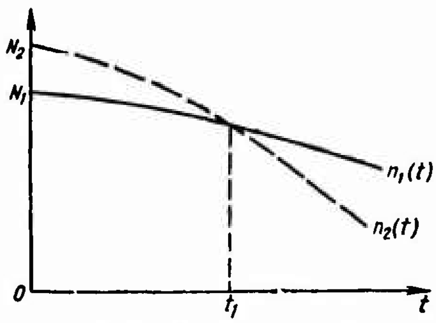


Figure 7.4.6. Change in Number of Tanks in Subunits in the Course of Combat (variant)

Prior to commencement of battle the subunit of adversary I contained fewer tanks than the subunit of adversary II, that is, $N_2 > N_1$. However, as a consequence of better quality of tanks and their more effective employment, the losses sustained by subunit II are considerably greater than those of subunit I, and at moment in time $t=t_1$ the numerical strengths of the subunits are equal. When $t > t_1$, subunit I will possess numerical superiority over subunit II. A computer can quickly furnish the results of a large number of combat variants in table and graphic forms, which can be analyzed and practically utilized.

With variable Λ_1 and Λ_2 (which in practice will almost always occur), equations (7.4.14) are not solved in elementary expressions; they must be solved numerically, on a computer, for example. Obviously these equations are also a mathematical model of combat between two groups of any similar weapons.

With constant Λ_1 and Λ_2, equations (7.4.14) are solved in elementary functions. A simple analytical model is obtained. To solve the equations, in this case it is convenient to proceed from n_1 and n_2 to relative quantities $\mu_1 = n_1 : N_1$; $\mu_2 = n_2 : N_2$. Obviously μ_1 and μ_2 can change within limits from 1 to 0.

We shall also introduce quantities α and $\bar{t}$:

$$\alpha = \frac{N_1}{N_2} \sqrt{\frac{\Lambda_1}{\Lambda_2}}; \qquad (7.4.15)$$

$$\bar{t} = \sqrt{\Lambda_1 \Lambda_2}\, t. \qquad (7.4.16)$$

Quantity α is called superiority indicator and determines the relative strength of the opposing forces taking into account quantity and quality of tanks.

If $\alpha > 1$, the capabilities of adversary I to deliver effective fire exceed the capabilities of adversary II, while when $\alpha < 1$ -- on the contrary, and when $\alpha = 1$, the capabilities of the opposing forces are practically identical.

Solving equations (7.4.14) with constants Λ_1, Λ_2, we obtain:

$$\left.\begin{aligned} \mu_1 &= \frac{1}{2}\left[(\alpha - 1)e^{\bar{t}} + (\alpha + 1)e^{-\bar{t}}\right]; \\ \mu_2 &= \frac{1}{2}\left[(1 - \alpha)e^{\bar{t}} + (\alpha + 1)e^{-\bar{t}}\right], \end{aligned}\right\} \qquad (7.4.17)$$

Where $e \approx 2.73$ -- base of a system of natural logarithms.

Computations according to the formula are performed with utilization of function tables $y=e^x$, $y=e^{-x}$.

Performing calculations with formulas (7.4.15-7.4.17), one can obtain for any moment in time from commencement of combat, what percentages of tanks μ_1 and μ_2 will remain in the opposing-force subunits. Knowing μ_1 and μ_2, we obtain $n_1 = \mu_1 N_1$, $n_2 = \mu_2 N_2$ and losses $r_1 = N_1 - n_1$, $r_2 = N_2 - n_2$.

One can demonstrate that if $\alpha > 1$, then for any moment in time $\mu_1 > \mu_2$ will occur, that is, the advantages of the stronger adversary will be maintained throughout the entire engagement.

For practical utilization of expressions (7.4.17), one plots in advance graphs for μ_1 and μ_2 in a function of $\bar{t}$ with various α (Figure 7.4.7).

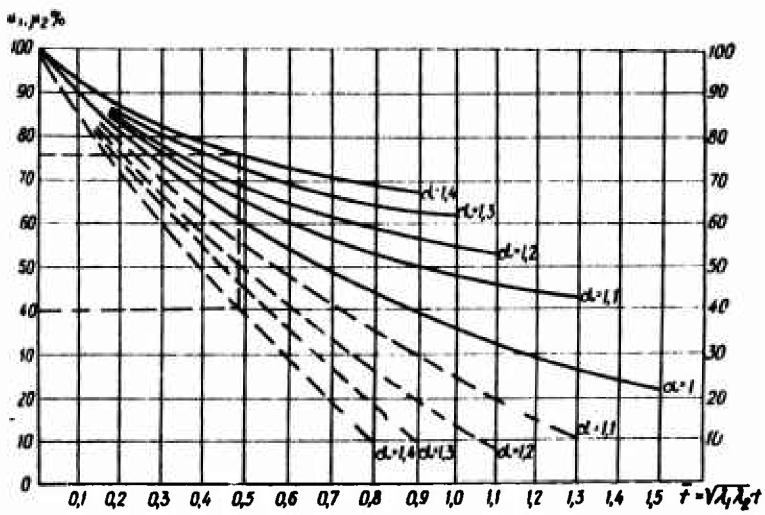


Figure 7.4.7. Graph of Simple Engagement Model

To utilize graphs μ_1 and μ_2 it is necessary to determine according to quantity α the stronger opponent and to assign him the number 1. We find two curves on the graph for quantity α. The upper curve (solid) determines change in relative number of still surviving tanks of the stronger subunit, and the lower curve (dashed) -- of the weaker subunit.

The curves show that the superiority of the stronger subunit over its adversary increases with time (the distance between the corresponding curves increases).

Example 8. Compare the combat capabilities of a tank subunit containing 25 tanks with the tank subunits of an adversary possessing 20 tanks, utilizing a mathematical model. The effective rates of fire of the tanks are constant and are equal to 0.30 and 0.25 effective rounds per minute respectively.

Solution. We shall utilize expressions (7.4.15 and 7.4.17) and the graph in Figure 7.4.7.

According to the condition $N_1=25$; $N_2=20$; $\lambda_1=0.30$; $\lambda_2=0.25$ there is a numerical superiority in favor of the first subunit: $N_1:N_2=25:20=1.25:1$. Taking into consideration the quality of the tanks, the superiority of the first subunit is even greater:

$$\alpha = \frac{25}{20}\sqrt{\frac{0{,}30}{0{,}25}} = 1{,}25\sqrt{1{,}6} = 1{,}4, \text{ т. е. } 1{,}4:1.$$

We find curves where $\alpha = 1.4$ on the graph in Figure 7.4.7. The upper (solid) curve will determine change in the relative number of tanks of the first subunit in the course of combat, and the lower (dashed) curve -- of its adversary (second subunit). For any moment in time t one can find μ_1 and μ_2 with these curves.

At that moment when the second subunit will still have 40 percent of its tanks, the first subunit will have approximately 75 percent.

In constructing a model one can eliminate a number of assumptions which were initially made. One can assume, for example, that one of the adversaries opens fire before the other, that the adversaries commit reserves at certain moments in time, etc.

All this naturally will affect the indices which determine the course and outcome of combat. For example, if subunit I, having executed a maneuver, mounts a spoiling attack on subunit II in the course of time $t = t_y$, we can show, utilizing equation (7.4.14), that N_2^1 tanks will remain in subunit II:

$$N_2^1 = N_2 - \Lambda_1 N_1 t_y. \qquad (7.4.18)$$

From the moment of mutual delivery of effective fire, one employs for calculations expressions (7.4.15 and 7.4.17) or the graph in Figure 7.4.6, where quantity N_2^1 is taken in place of N_2, etc.

Example 9. A tank subunit, having executed a maneuver, attacked the flank of an enemy tank subunit and mounted a spoiling attack for $t_y = 2$ minutes. Determine the ratio of fire capabilities of the subunits before and after the spoiling attack. Initial data: $N_1 = 25$ tanks, $\Lambda_1 = 0.25$ for the first subunit; $N_2 = 30$ tanks, $\Lambda_2 = 0.20$ for the second.

Solution. The coefficient of commensurability prior to attack, according to formula (7.4.15) is

$$a_1 = \frac{25}{30} \sqrt{\frac{0,25}{0,20}} = 0,9 < 1.$$

The fire capabilities of the second subunit are greater than those of the first, with a ratio of 1.1:1 in its favor.

Following the spoiling attack, the adversary will retain the following, according to formula (7.4.18):

$$N_2^1 = 30 - 25 \cdot 0.25 \cdot 2 = 18 \text{ tanks}.$$

The coefficient of commensurability will be:

$$a_2 = \frac{25}{18} \sqrt{\frac{0,25}{0,20}} = 1,6 > 1.$$

The fire capabilities of the first subunit have become significantly greater than those of its opponent -- 1.6:1 in favor of the former.

A mathematical model determined by expressions (7.4.15-7.4.17) is an example of a simple model. It enables one to elucidate influence on the course of combat determined by the magnitudes of losses, the ratio of tanks and their principal performance characteristics Λ_1 and Λ_2. Quantities Λ_1 and Λ_2, as stated above, are dependent on tank performance characteristics, type of engagement, methods of fire, etc. Consequently, with these quantities one can more thoroughly estimate the influence of a number of basic factors on the course of combat.

Mathematical models of more complex variants of combat operations (various weapons, consideration of terrain, displacement of the opposing forces, control, etc) are constructed similarly to the model examined above. One obtains more complex mathematical expressions, and in larger quantity. More complex and laborious calculations are performed for their utilization.

Statistical Model

Considered random factors are played out (simulated) in statistical models, after which the influence of their concrete values on the course of the process of combat operations is determined by conventional methods. After one process realization on such a model, the values of the sought quantities will be random; general conclusions cannot be drawn from them on the course and outcome of the target process. Therefore the process is played out repeatedly on the model, as a result of which one obtains statistical data on its progress. The requisite synthesized characteristics are obtained after processing the statistical data.

Let certain random event A, with a probability of p be considered. We shall designate as a model of this event a certain other event A*, the probability of which is also p, Bep (A) = Bep (A*). Usually an easily reproducible event is taken as event A*.

It is demonstrated in probability theory that event A* constitutes a model of any random event A with probability p; a number less than p is selected in one trial from a table of random numbers or a random-number generator. The latter is easily accomplished.

For example, we examine a random event -- a kill scored on an enemy tank with one round fired. Let the probability of this event be p=0.8.

To play out this event on a model, we must take number ζ from a table of random numbers and check inequality $\zeta < 0.8$. If $\zeta < 0.8$ occurs, the event of tank kill has taken place on the model. If $\zeta \geq 0.8$, the tank has not been killed. In like manner a random event is played out on a computer with the aid of a random-number generator.

Utilizing a table of random numbers or random-number generator, one can also play out many random phenomena determined by one or several random quantities. But for this it is necessary to determine in advance the distributions of these random quantities. Therefore construction of statistical models of combat operations is preceded by investigation of random factors influencing them, with the aid of the edifice of statistics and probability theory.

Example 10. Construct a statistical model of a duel between tanks. This engagement is represented as follows. The crew of the first tank spots the enemy tank and is the first to fire off a round. If the enemy tank is not destroyed, it fires a response round at the first tank. If the first tank is not destroyed by the first response round, a second round is fired at the enemy tank, etc.

The outcome of this engagement is of course random, and it can be estimated by probability of victory p_1 of the first tank over the second tank, which is equal to the probability of killing the enemy tank.

A statistical model can be constructed to determine the probability of victory. It is necessary in advance to be able to compute the probabilities of killing the enemy and the first tank with the first, second, etc rounds fired. As we know from gunnery theory, this problem is fairly simple to solve with the aid of appropriate tables. Ranges to targets and adjustments are of course also considered.

Let enemy tank kill probabilities be p^i(i=1, 2, ..., n), where i is the serial number of the round fired. Probabilities of killing the first tank are q^j, where j is the serial number of the enemy's response round (j=1, 2, ..., n). Figure 7.4.8 contains a statistical model variant algorithm.

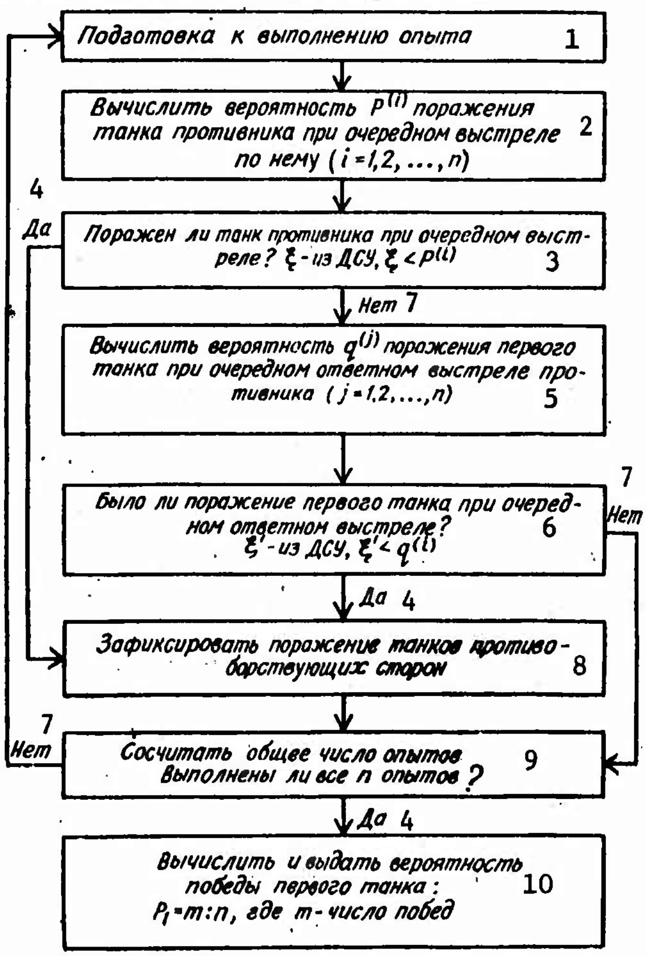


Figure 7.4.8. Algorithm of Statistical Model of Tank Duel (variant)

Key to Figure 7.4.8 on preceding page:

1. Preparation for performance of test
2. Compute probability $p^{(1)}$ of killing enemy tank on a given round fired at it
3. Was the enemy tank killed with a given round fired?
4. Yes
5. Compute probability of killing the first tank with a given enemy response round
6. Was the first tank killed with a given response round?
7. No
8. Record tank kills of opposing forces
9. Count the total number of tests. Have all n tests been performed?
10. Compute and give probability of victory of the first tank: ... where m -- number of victories

To determine probability of victory p_1, one employs a known law from probability theory that the frequency of a random event, with a sufficiently large number of tests, is approximately equal to the probability of the event.

If n tests have been performed on the model, in which our tank has "killed" the enemy tank m times, then with a sufficiently large number n, probability of victory will be

$$p_1=\frac{m}{n}\ .$$

The probability of victory of the enemy tank is obviously $p_2=1-p_1$. The number of tests n (engagement playthroughs on the model) is calculated in advance, in order that the accuracy and reliability of the obtained results be sufficiently high.

Statistical models of more complex processes are constructed in like manner, where a large number of random factors are considered.

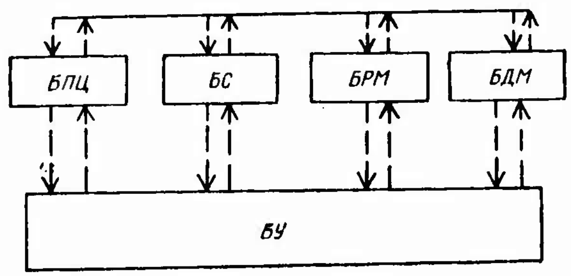


Figure 7.4.9. Algorithm of a Statistical Model of an Engagement Between Subunits

Figure 7.4.9 contains a diagram of a statistical model of a tank subunit offensive engagement. The model consists of a number of information-interconnected units: a target search unit (БПЦ), a firing unit (БС), a control unit (БУ), a terrain relief unit (БРМ), and a movement and maneuver unit (БДМ). The function of the units is clear from their designations. Groups of specific actions performed by all tanks in the course of combat are simulated in each of them (target search, firing, etc).

The defending enemy force essentially has analogous units for simulating two-sided combat. Simulation results include enemy losses, probability of victory, situation of the opposing forces in time, etc.

Combined Simulation of Combat Operations

This is a method of simulating combat operations which combines real actions by a human operator (commander) and mathematical models. We know that the role of the human operator (commander, officer, soldier, etc) is very large in the course of combat operations. It is very difficult, almost impossible, however, to simulate the human operator's actions and moral-political state.

Therefore combined models are employed, in which only those stages of the process of combat operations are simulated which can be mathematically described comparatively easily, while decision-making processes are not simulated but are performed by an actual operator (commander).

Mathematical models provide needed information for decision-making as well as results which evaluate a decision variant.

This simulation method is considered promising for examining the capabilities of tank forces, in predicting the results of combat operations, and for training command personnel.

A structural diagram of the functioning of a combined model is similar in many ways to the structure of a two-sided war game conducted on maps.

Although mathematical models are playing an ever increasing role, one should bear in mind that they furnish for the most part quantitative indices; they do not take into consideration a large number of quantitatively unexpressed but very important factors. Therefore simulation results are used as a quantitative foundation for decision-making and planning, and these results should be refined by the commander and staff officers on the basis of concrete situation facts. Mathematical models of combat operations do not replace the commander but greatly assist him in troop control under the complex conditions of modern combat.

5. Application of Critical-Path and Control Methods

Example 11. The "Red" force is mounting an offensive operation, in the course of which it is necessary to employ helicopters for transporting personnel and equipment. Figure 7.4.10 shows the duration of employment of helicopters, the character of their utilization, and the required number of helicopters for performing each job.

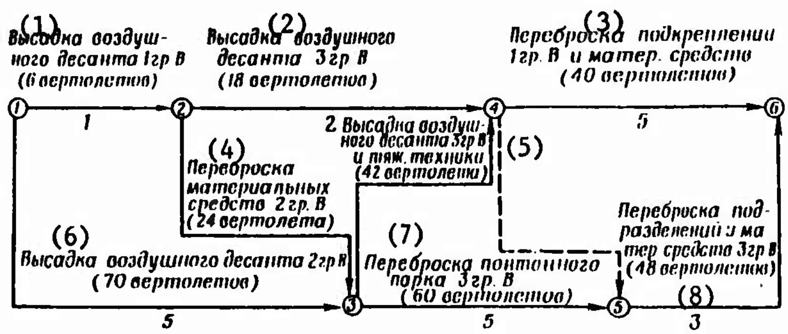


Figure 7.4.10. Initial Operation Network Schedule

Key to Figure 7.4.10 on preceding page:

1. Delivery of first force grouping airborne assault (six helicopters)
2. Delivery of third force grouping airborne assault (18 helicopters)
3. Helilifting of first force reinforcements and supplies (40 helicopters)
4. Helilifting of second force supplies (24 helicopters)
5. Delivery of third force airborne assault and heavy equipment (42 helicopters)
6. Delivery of second force airborne assault (70 helicopters)
7. Helilifting of bridge train of third force (60 helicopters)
8. Helilifting of third force subunits and supplies (48 helicopters)

The helicopters must be distributed in such a manner that their outlay does not exceed 20 units per day, because the higher commander cannot assign a greater number of helicopters.

Solution. 1. We shall construct an operation initial network schedule on the basis of the commander's battle map (Figure 7.4.10). We calculate the network schedule. We take duration of jobs $t_{(i,j)}$ from the conditions of the conducted operation (in our example from the initial network schedule). In calculating the network schedule we compute the partial reserve of second-type jobs $P''_n(i, j)$, which shows how many days later each job can end, and we enter the result in column 4 of Table 7.4.2.

Table 7.4.2. Linear Chart

№ по пор.	Код работы (1)	$t_{(i,j)}$	$P''_n(i,j)$	Д					Н					И					
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1—2	1	0	6															
2	1—3	5	0	14	14	14	14	14											
3	2—3	3	1		8 / 6	8 / 6	8 / 6	6											
4	2—4	2	8		9	9			3	3	3	3	3	3					
5	3—4	6	0						7	7	7	7	7	7					
6	3—5	5	1						12 / 10	12 / 10	12 / 10	12 / 10	12 / 10	10					
7	4—5	0	0																
8	4—6	5	0												8	8	8	8	8
9	5—6	3	2												16 / 12	16 / 12	16 / 12	12	
10	Число вертолетов до оптимизации (на каждый день) (2)			20	31	31	22	14	19	19	19	19	19	7	24	24	24	8	8
11	Число вертолетов после оптимизации (на каждый день) (3)			20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	8

Key to Table 7.4.2 on preceding page:

1. Job code
2. Number of helicopters before optimization (for each day)
3. Number of helicopters after optimization (for each day)

Symbols: $t(i,j)$ -- duration of employment of helicopters, in days;
$P''_n(i,j)$ -- partial reserve of second-type jobs, showing how many days later the job can begin.

---

2. We construct a linear charge on the basis of the network schedule and its calculation table (Table 7.4.2).

Initially we place quantities on the chart as determined in the initial network schedule (solid lines). For example, job (1, 2) runs one day. In the fifth column, on the first day of the operation we [illegible] the duration of this job with a solid line segment one day in length, [illegible] it we indicate a specific number of helicopters (six helicopters). Job (1, 3) runs five days and begins parallel with job (1, 2). We place it in the second line, beginning on the first day of the operation and running to and including the fifth. Since 70 helicopters are required for job (1, 3), and its duration is five days, 14 helicopters will be required for each day (70:5). We place this number in each day of the operation in the second line, from the first to the fifth day inclusive. The entire linear chart is constructed in like manner.

3. We add the number of helicopters for each day (on the basis of the first construct) and enter it in line 10. An analysis of line 10 shows that the conditions of the mission are not met: on some days (2, 3, 4, 12-14) the number of helicopters exceeds 20.

4. We perform optimization of the linear chart, for which we continue the solid line segments with dots to the extent of time reserve $P''_n(i,j)$. In line three, for example, job (2, 3) has a one-day reserve. We add one day with dots to the solid line segment and obtain an overall duration of four days.

In the fourth line the time reserve is 8. We increase the solid line segment with dots by an additional 8 days. We perform the entire operation in like manner.

We then distribute helicopters among the columns, taking into account job duration with time reserve $P''_n(i,j)$, in such a manner that no more than 20 helicopters are employed each day, and we mark the optimized lines with a wavy line, maneuvering within the limits of the entire duration of the operations.

In line three, for example, job (2, 3) previously had a duration of three days, and eight helicopters were required each day for its performance. It can run four days taking time reserve into account. We mark its new duration with a wavy line and place six helicopters in each day (24 x 4). We proceed in like manner with all rows and columns. We enter the results in row 11. As is evident from Table 7.4.2, the problem is solved: not more than 20 helicopters are employed each day.

SECTION VIII. TANK TROOPS COMBAT SERVICE SUPPORT

Chapter 1. GENERAL CONSIDERATIONS

The conduct of combat operations by tank troops requires a large expenditure of ammunition, fuel and other supplies. In order to provide troops the capability to conduct continuous combat operations for an extended period of time and to maintain their combat efficiency, they must be continuously resupplied. The scale of hauling of supplies as well as the quantity of expended and consumed supplies increase with increasing sophistication of equipment and weapons, which is one of the important points of logistical support.

Employment of nuclear weapons and other powerful weaponry and the high degree of effectiveness of antitank weapons can lead to substantial casualties and losses of equipment and supplies. In connection with this it is noted that a high degree of combat readiness and fighting efficiency of tank troops in today's warfare will depend to a significant degree on combat service support.

The principal task of combat service support is complete, prompt and timely supply and medical support of troops. The job performed by the rear services should be of a planning and forecasting nature and should meet such requirements as flexibility, continuity, reliability, promptness, timeliness, and effectiveness. Successful performance of missions by the rear services can be achieved with continuous and firm control of combat service support resources, a high degree of preparedness, proper disposition in depth, and efficient utilization of all modes of transportation for hauling supplies.

A characteristic feature in the work performed by the tank troops rear services is not only a large and continuously growing volume of hauling of materiel as a whole, but also the ratio of consumable supplies. For example, the volume of hauling of supplies per unit of equipment has increased severalfold in comparison with the past war. Fuel and lubricants will comprise more than half of total troop requirements in basic supplies. Fuel has become one of the principal and determining categories of tank troops supply.

The fact that tank troops operate a large quantity of equipment, the intensive operation of this equipment in the course of combat employment, and the possibility that large numbers of vehicles can be put out of commission as a result of employment of various weapons give exceptional importance to combat service support. The principal task of this support is to maintain equipment and weapons at a level ensuring a high degree of combat efficiency, with the requisite technical

superiority over the enemy. This task is accomplished by achieving excellent mastery of equipment, correct organization of its operation and maintenance, and rapid repair and recovery of vehicles directly in the course of combat operations.

We should particularly note the importance of repair and recovery of equipment, particularly tanks, in maintaining the combat efficiency of tank troops. For example, with conditionally adopted average daily equipment losses amounting to 10-12 percent of equipment, and absence of repair and recovery, by the end of the fifth day of combat operations a force will have only 40-50 percent of the original number of battleworthy units of equipment. If the given force has repair facilities at its disposal, ensuring repair and recovery of 60-70 percent of losses, the number of battleworthy units will not drop to 40-50 percent of the original number until the 12th-16th day of combat operations. Thus the duration of combat operations of a force increases 2.4-3-fold with the number of battleworthy units of equipment declining to the specified level. Herein lies the operational-tactical significance of tank repair and recovery.

The importance of equipment repair and recovery for maintaining the combat effiency of tank troops is particularly clearly evident in a theater of operations which is isolated from the home front of the belligerent nation, when capability to replace losses with delivery of equipment from industrial plants is extremely limited.

In the battle of El Alamein, for example, between 23 October and 3 November 1942 German-Italian losses totaled 450 tanks, while the British lost 500 tanks. During the period of combat operations, British repair and recovery facilities were able to repair and return 337 tanks to service, while in the German and Italian divisions the tank force was not returned to strength by repairs, due to the extremely limited capabilities of their repair and recovery service.

In this battle the British repair and recovery service played the major role in shifting relative strengths in tanks in favor of the British. At the commencement of the battle of El Alamein the German 15th and 21st Panzer divisions had 230 tanks at their disposal, while by the end of the battle these two divisions possessed only 80 tanks. Subsequently the British numerical superiority in tanks, established by recovering and repairing tanks, was one of the main factors ensuring the British victory in Libya over the German-fascist and Italian forces.

In the operations of the Great Patriotic War recovery and repair of tanks by repair facilities was the principal source of replacing losses. In the L'vov-Sandomierz Operation, for example, the number of repaired tanks and self-propelled guns in the 3d Guards Tank Army significantly exceeded the number of combat vehicles possessed by the army at the commencement of the operation.* Some tanks were returned to the line for combat two or three times.

During the conduct of modern combat operations with employment of nuclear weapons and more powerful antitank weapons, considerably more vehicles may be disabled than in the past war. The possibility of increased losses is confirmed by the experience

---

* See A. I. Radziyevskiy, "Tankovyy udar" [Tank Attack], page 217.

of recent local wars. Therefore greater-capacity repair facilities may be required in order to maintain the combat efficiency of tank troops.

Under present-day conditions, in connection with an increase in the tempo of attack, a lack of extended pauses in the course of combat operations, and an increase in depth of missions performed by forces, there is also a substantial increase in the intensity of equipment operation in the course of combat employment, which will require more thorough preparation of equipment, prompt and timely execution and precise organization of equipment servicing.

Thus well organized combat service support will make it possible to maintain a high level of tank troops combat efficiency during the entire period of combat operations and will make it possible to increase the duration of their continuous combat employment and thus to achieve high combat efficiency.

The rapid pace and maneuver character of the combat operations of tank troops and a large scale of employment of nuclear weapons and diversified combat equipment create specific features in combat service support activities.

The specific features of tank troops combat service support activities proceed from the character of their combat employment and the combat missions they perform. Tank troops will operate in the enemy's operational rear, sometimes separated from other friendly forces, and on disconnected axes. Therefore in order to accomplish their tasks reliably, combat service support agencies should accompany the tanks under all conditions and be positioned in the immediate vicinity of the combat troops. A high level of technical equipment of combat service support agencies is an essential condition for accomplishing these tasks.

Equipping of the rear services is performed in the following basic areas: extensive adoption of air transport means, large-payload trucks with good cross-country performance, and various equipment for performing loading and off-loading operations. In order to improve control and the efficiency of combat service support, the NATO nation armies employ automated servicing and repair management systems and closely supervise and monitor the delivery of material to the troops.

U.S. rear services experts believe, for example, that the adoption of automated logistical management systems will make it possible in a future war to accomplish more efficiently and effectively tasks of supply and logistical support. For example, since adoption of a mobile automated supply record keeping system,* supply specialists spend only 70 seconds instead of two hours on drawing up and coordinating with higher agencies requisitions for replenishment of consumed supplies and determining the point and routes of delivery of the ordered supplies.**

One important condition for combat service support agencies to accomplish their tasks is the survivability of combat service support agencies. Employment of

* DSU/GSU (Direct Support Unit/General Suport Unit).
** See "Automation of Logistical Support Processes in the U.S. Army," ZARUBEZHNOYE VOYENNOYE OBOZRENIYE, No 10, 1975, page 33.

nuclear weapons against combat service support personnel and important facilities can lead to the destruction of supplies, to substantial destruction along supply and evacuation routes, and to knocking out of action or loss of combat efficiency of combat service support units and subunits. Therefore in order to ensure combat service support survivability, rear services units and establishments will probably be dispersed and well protected against the effects of various weaponry.

Tank troops combat services support is organized in conformity with the commander's decision and plan for conduct of combat operations and the situation. Principal combat service support efforts should always be directed toward supporting the force operating on the main axis of advance, and the positioning of combat service support personnel and facilities should conform to the tactical order of battle and the missions being performed by the combat troops.

The distance between combat service support facilities location areas and troop combat formations depends on the content and nature of the combat missions and situation conditions. There exist, however, general rules of positioning, determined by the specific features of the tasks performed by the various subunits and units. Medical facilities are brought closer to the combat troops in all types of combat activities, as are facilities and equipment for recovery and repair of tracked armored vehicles.

Evaluating the importance and specific features of combat service support activities as a whole under conditions of combat operations, foreign military experts note that it is comparatively easy to change tactical plans, to assign troops a new sector and to assign new missions in rapid fashion, but it is considerably more difficult to bring combat service support plans into conformity with the altered tactical mission, since this will require changing the disposition of supply facilities, the sequence and procedure of employment of combat service support personnel and facilities, and enlistment of additional personnel and facilities. Therefore the commander, when working on tactical problems pertaining to the assigned mission, should always adequately deal with those matters pertaining to combat service support which form the genuine foundation of the plan of operations.

Chapter 2. COMBAT SERVICE SUPPORT

In all armies it is acknowledged that combat service support operating methods under conditions of tanks troops combat operations, as well as the content of combat service support do not remain constant. They change together with change in the forms and methods of organization for combat and tank troops equipment and weapons.

However, the general requirements imposed on combat service support activities, on supply, maintenance and medical support, remain unchanged. They include prompt and complete provision of all requisite supplies to the troops; continuous maintenance of equipment in good working order and utilization readiness; rapid recovery and return to service of damaged vehicles; prompt medical assistance to personnel.

1. Combat Service Support During a March

In all armies considerable attention is devoted to matters of combat service support during troop movements, since promptness, timeliness and completeness of support activities determine in large measure the speed of troop maneuver and troop combat efficiency on engagement.

Usually during march preparations combat service support subunits replenish supplies in the line units and supply depots, perform evacuation of excess equipment and transfer of sick and wounded to the medical facilities of the higher commander. At the same time maintenance is performed on combat service support trucks and equipment, and preparations are made for transporting supplies.

The specific content and organization of the enumerated measures will depend in each instance on availability of time for march preparations, the tactical situation and conditions in which the march is to be accomplished, the nature of missions performed by the troops after the march, and the state of the rear services.

In the opinion of foreign experts, success in combat service support activities during a march is grounded on bringing as close as possible to the troops those combat service support personnel, vehicles, equipment and supplies which ensure troop mobility. These supplies include first and foremost fuel and lubricants. Therefore supply vehicles carrying fuel and other indispensable supplies travel immediately behind or with tank subunits. It is necessary to ensure that combat service support subunits do not decrease the maneuver capabilities of tank troops.

When troops are advancing to contact, principal combat service support vehicles proceed in one or two independent columns at a distance ensuring prompt and timely accomplishment of logistical and medical support missions. Distance between combat service support trains and the main forces depends on the conditions of execution of the march, and in particular the tactical situation.

Under difficult conditions, when wheeled vehicles cannot proceed in a single column with tracked vehicles, as well as during a long-distance march, all combat service support trains may travel by a designated route in independent columns. In some instances, where there is no threat of encountering the enemy, combat service support personnel, vehicles and equipment can advance into halt areas and the destination concentration area ahead of the combat units.

Efficient arrangement of the combat service support trains is an important requirement on disposition of the rear services during a march. They will be arranged in such a manner that those combat service support elements and supplies will be located closer to the head of the column which may be required first of all during the march and in the forthcoming engagement. When forming up the rear services support columns, each column should contain the requisite quantities of supplies.

Tank troop movements will be characterized by large consumption of fuel and lubricants, as well as antiaircraft weapon ammunition under conditions of intensive air opposition. Therefore during movement of tank troops, especially long distances, larger quantities of these supplies will probably be established.

It is noted in the foreign press that during a march vehicles should be refueled and resupplied with lubricants during halts or on arrival in the destination area, and during a march of several days -- on halts and in rest areas. If the situation permits, refueling points can be set up in advance in areas where fueling is to take place. During execution of a march in anticipation of engagement, refueling points are selected so that when troops reach the point of anticipated contact with the enemy, fuel in vehicle tanks is sufficient to perform assigned missions without additional refueling.

Replenishment of other supplies will evidently be accomplished when troops reach the destination areas, in rest areas following a day's march, or in combat service support disposition areas during deployment of troops for combat, to which the required supplies will be hauled by truck. In conditions where trucks with supplies are unable to accompany tank columns, especially when crossing extensive areas of high radiation levels, requisite supplies may be airlifted, while fuel can also be conveyed by pipeline.

Logistical support is an important factor in maintenance by tank troops of a high degree of combat readiness during movement, especially long distances. In order to ensure reliable vehicle operation without breakdowns and to achieve high rates of march, march preparations should include training of truck and armored personnel carrier crews and drivers, as well as personnel of maintenance vehicles and facilities, preparation of vehicles and vehicle maintenance equipment for the march, and replenishment of carried supplies of armored vehicle and truck equipment.

Dissemination to personnel of the most typical features of driving, servicing and repairing vehicles in the conditions of the impending march is the principal content of technical preparation.

It is believed that the combat readiness of equipment during a march is determined first and foremost by prompt, timely and high-quality performance of servicing and maintenance procedures on vehicles during preparation for and in the course of a march. Initial data for determining the extent of vehicle servicing and maintenance can include the following: availability of time for march preparations; vehicle mileage to the next major maintenance; possible vehicle mileage in accomplishing the march and subsequent performance of combat missions; technical condition of the vehicles and operating conditions; possible nature of the combat missions which are to be performed after the march. The extent of vehicle servicing and maintenance is established so that when vehicles reach the destination there will be adequate mileage remaining for accomplishing the assigned mission before the next scheduled maintenance.

Practical operating and maintenance experience indicates that the operating reliability of vehicles decreases with an increase in mileage on a vehicle. Therefore when determining the extent and timetable of activities to ready vehicles for a march, one takes into account vehicle mileage and operating conditions. Usually a greater quantity of preventive maintenance is performed on vehicles with less mileage remaining to the next maintenance, in order to ensure their operating reliability during the march. If it is not possible to accomplish the scheduled work in the time allocated for march preparation, an expedient sequence of performance of maintenance operations is specified, with priority to the most important operations, which determine vehicle combat readiness and mobility. Remaining maintenance should be performed on halts during the march or in the concentration area.

Stocks of armored vehicles and truck supplies at supply depots and in maintenance subunits are replenished during march preparations. One takes into account conditions of travel and the technical condition of the vehicles, since consumption of repair parts during a march is determined in large measure by these factors.

Capabilities to perform vehicle maintenance are extremely limited during a march. Some requisite maintenance procedures are performed on halts, while the remainder are performed in rest areas in the concentration area following the march. The duration and number of halts, as well as the time spent by troops in rest areas should be sufficient for performance of requisite servicing procedures to maintain vehicles in a battleworthy state. If laborious maintenance operations must be performed during a march, which is characteristic of long distance marches, procedures can be performed sequentially, at two times. Maintenance and repair elements will be called upon to perform the most complex operations. The need to perform repair operations during a march is dictated by breakdowns occurring during vehicle operation and by damage sustained in combat.

It is believed that repair and recovery activities during a march will be performed by support assets assigned to the march column technical maintenance echelon. The composition of these resources depends on the anticipated volume of repair operations during the march and the character of the forthcoming missions. Depending on the enumerated conditions, up to one half of available maintenance resources are usually assigned to the column technical maintenance echelon. Remaining resources continuously proceed with the combat troops and advance with them to the point of contact with the enemy, prepared to perform repair and recovery activities

during combat. During a march covering several days, these means perform maintenance operations in rest areas and take part in readying equipment for the following day's march.

It is acknowledged that such a disposition of maintenance resources in depth during a march is the most efficient, since it provides for repair and recovery of equipment both along routes separated from the combat troops and directly in the subunits and units.

In view of the considerable difficulty of recovery of tracked vehicles which have broken down during a march, they should be repaired at the point of breakdown. As regards trucks and other vehicles, they can be repaired on the spot, or towed forward to a designated damaged vehicle collection point, depending on the nature of the breakdown or damage, state of the roads, and other conditions. Usually only those vehicles which cannot be towed are repaired at the breakdown point.

Since it is a very complicated matter to manage and control maintenance means engaged in repairing equipment on routes of march, it is recommended that the duration of their work activities be limited. During a march, in anticipation of engagement from march formation, the maximum duration of work activities by technical maintenance echelon means is determined so that the bulk of these assets can take part in repairing equipment in the forthcoming engagement. During conduct of a march lasting several days, it is considered advisable for the maximum duration of work activities by column technical maintenance echelon equipment to be set so that the technical maintenance echelon and the repaired vehicles can catch up with their units in a rest area and commence the next day's march together with them.

The rate of march of tank columns can become significantly reduced when negotiating difficult stretches of terrain and especially when vehicles break down. Therefore when routes of march contain such difficult stretches as rivers which must be forded, mountain passes or defiles, recovery and repair equipment should be sent out to ensure unhindered movement of the columns.

As is noted in the foreign press, in the course of marches, as a consequence of long distances covered by troops, maneuver of logistical support personnel and equipment is restricted. Therefore helicopters can be used to conduct technical reconnaissance of routes, to spot vehicles requiring technical assistance, and to deliver to these vehicles maintenance specialists and required repair parts.

It is believed that when crossing radioactive contamination zones, depending on the level of radiation and size of the contaminated area, maintenance equipment can follow the columns in the same disposition, can wait for radioactivity to drop to a safe level, or can detour around the zone following a new route. When necessary a technical maintenance echelon employing prime movers or other armored vehicles can be organized to follow the troop columns crossing such a zone.

2. Combat Service Support in the Attack

One of the main demands imposed on the rear services in the attack is a correct combination of displacement of rear services behind the attacking troops, with

efforts to ensure continuous, full provision of supplies to the troops, as well as prompt and timely performance of requisite medical evacuation measures.

Prior to the commencement of an offensive operation, combat service support resources are positioned in their assigned area within the boundaries of the overall combat troops disposition area and see to the transport and replenishment of supplies and preparation of combat service support elements to provide supply and medical support during the attack. Medical facilities are freed by transferring sick and wounded to facilities of the higher commander, and combat service support trucks and equipment are readied.

It is recommended that areas designated for positioning rear services provide natural screening and shelter for protection against enemy weapons of mass destruction.

When troops are advancing to the final coordination line, their combat service support elements can be disposed in depth. This is done for the purpose not only of prompt and timely supply and medical support as the attack commences but also to disperse supplies and combat service support elements and to diminish the possibility of these elements being hit by hostile fire.

During the attack it is considered advisable not to permit combat service support elements to become greatly separated from the combat troops. This requirement applies first and foremost to medical personnel and facilities, which should always be close enought to the troops so that casualties can always receive prompt medical assistance. One must bear in mind, however, that too frequent displacements of rear service support elements diminish the efficiency of their work.

Combat service support elements should reach the dispositions of the combat troops by the evening of the day of the battle and during withdrawal of troops into the reserve, and should replenish consumed supplies and ready the troops for subsequent operations. The sequence and procedure of replenishing supplies are determined by commanders on the basis of consumption, established supply standards, and situation conditions. First priority is given to subunits and units operating on the main axis of advance. Usually tanks and other combat vehicles are reammunitioned and refueled when subunits are withdrawn into the reserve and at points designated by the commander. When necessary, tanks are reammunitioned and refueled directly in combat formations, behind cover.

Prompt and timely hauling of supplies is an essential condition for uninterrupted resupply during an offensive operation. In organizing the bringing up of supplies, delivery of supplies should be accomplished with a minimum of load transfers. Therefore, if the situation permits, supplies can be delivered directly to the combat subunits by transport resources of the higher commander.

In case of interruptions in supply in the course of an offensive operation, stocks of supplies can be shifted, involving redistribution both within a subunit and between subunits.

When tank troops are operating separated from the remaining forces, as well as when major physical damage occurs on supply routes, supplies can be airlifted.

Foreign military experts believe* that air transport has a big future in the combat service support system and opens up new possibilities for further improving methods of logistical support of tank troops in the attack. First of all employment of helicopters is proposed for combat service support activities. It is believed that helicopters can be employed in massive numbers to support large-scale tank troops offensive operations. The employment of helicopters in the combat service support system could lead to change in the organization and equipment of tank troops as well as the tactical principles of their employment in the offensive operation, since tank troops freed of ground lines of communication, which are extremely vulnerable in present-day conditions, can more effectively utilize their combat capabilities in operations separated from other forces.

As a rule combat service support during preparation for an offensive operation includes measures pertaining to technical training of personnel, preparation of equipment for reliable operation, repair of vehicles damaged in preceding combat actions, and transfer of unrepaired vehicles to the assets of the higher commander, readying of repair and recovery equipment and facilities, and establishment of requisite supplies of armored vehicle and truck repair parts.

All vehicles which cannot be repaired and returned to service in time for forthcoming combat operations are handed over to maintenance units of the higher commander.

Combat service support subunits are usually readied in the process of performance of vehicle repair and recovery tasks. There should be adequate time, however, to complete their work and for checking readiness of combat service support means.

During an offensive operation, the main combat service support tasks include prompt, timely and complete servicing of vehicles and their rapid repair upon becoming disabled. The time and place of performance of vehicle servicing and maintenance during an offensive operation are determined by the mileage they run up. It is usually considered that servicing should be performed toward evening on a day of combat and when subunits are withdrawing into the reserves (support echelon), with securement of the required troop combat readiness and continuity of combat operations. In order to speed up the performance of servicing and maintenance, combat service support equipment (maintenance vehicles, fuel tankers, mobile maintenance shops, etc), as well as consumable materials and ammunition can move up in advance toward the combat formations of the subunits. A priority during servicing and maintenance is given to restoring vehicles to battleworthiness (refueling vehicles and replenishing ammunition).

As troops advance to the line of departure, battalion trains can advance behind their battalions, and unit maintenance subunits behind their main forces, designating a technical maintenance echelon for each route. Battalion means are usually called upon to repair vehicles during advance to the line of departure; their principal task is to perform recovery and repair operations from the commencement of combat as elements of battalion repair and recovery teams.

* See J. Gibson, "Air Lines of Communication for Armored Troops," MILITARY REVIEW, April 1974, pp 25-30.

Vehicles which have become disabled during advance to the assault phase are repaired by organic means in sheltered locations close to the routes of movement. These resources can be assigned repair tasks of a duration which would make it possible to begin in a prompt and timely manner repair of vehicles which have become disabled during combat. In conformity with these requirements, duration of repair operations by technical maintenance echelon resources is limited to several hours.

In the course of combat the duration of operations by battalion repair and recovery teams is determiend so that they can take part in vehicle servicing and maintenance on battalion withdrawal to the support echelon or reserve.

When the assault phase commences, repair and recovery teams are positioned immediately behind the combat formations close to technical observation posts and evacuate damaged vehicles from under hostile fire to sheltered positions and to an evacuation route, determine their conditions and perform brief minor vehicle repairs behind cover.

In the course of an offensive operation, depending on the quantity, location and nature of damage of vehicles, their repair by the resources of maintenance subunits is performed at the locations where they become disabled or at collection points set up at the locations of a large number of damaged vehicles. Maximum duration of work by repair means at a single location, and consequently the distance by which they lag behind the unit's formation depend on the availability of repair means, the extent and nature of the repair stocks, the rate of troop advance and the tactical situation, as well as repair resources control capabilities. In order to prevent repair equipment from falling considerably behind the combat troops and to ensure reliable control of these means and priority repair of vehicles with minor damage, as well as participation by maintenance personnel and equipment in readying vehicles for the following day of combat operations, the bulk of maintenance resources advance to the combat subunit prior to commencement of preparation of vehicles for subsequent combat operations.

The experience of the past war indicated that correct determination of working time by maintenance personnel and equipment at a single location exerts considerable influence on the efficiency of their utilization and consequently on the number of vehicles repaired and returned to service. Therefore when determining job assignments for repair personnel and equipment one should proceed not only from the distance by which they may become separated from the unit combat formations but also from the necessity of obtaining excellent work performance efficiency.

Of considerable importance in achieving a high degree of work efficiency by repair personnel and equipment is skilled maneuvering of this personnel and equipment. Therefore when organizing vehicle repair it is essential to ensure that repair personnel and equipment immediately proceed to troops which have sustained heavy equipment losses, in order quickly to restore their battleworthiness.

Vehicles damaged in combat will be evacuated first to nearby sheltered locations, and subsequently to repair facility deployment sites. In order to ensure rapid advance of repair and recovery equipment to vehicles not restored to service by combat unit means, as well as to speed up their transfer, recovery and repair, it is

recommended that these vehicles be concentrated at prior designated points. It is believed that the number of such points will be established proceeding from terrain conditions and recovery capabilities.

Replenishment of maintenance subunit and unit stocks of armored vehicle and truck repair parts is accomplished continuously during combat by requisitioning from supply facilities. Stocks at supply facilities are usually replenished at the end of a day of combat operations. If required repair parts are not available, parts and assemblies removed from vehicles not to be returned to the line are utilized.

3. Combat Services Support in the Defense

Incomparably more complex conditions are created for combat service support activities during the conduct of defensive combat by tank troops than in other types of combat activity. The complexity of combat service support activities in the defense is due to the possibilities that the enemy will penetrate the dispositions of the defending forces and will reach supply and evacuation routes as well as combat service support facilities deployment areas. Therefore, it is noted in the foreign press, in the defense tank troops combat service support elements will be dispositioned in such a manner that temporary adverse situation changes caused by enemy penetration will not disrupt rear services supply and medical support activities and will not require significant changes in its disposition. Proceeding from these requirements, combat service support means will most frequently be positioned at a greater distance behind defended positions than in the attack.

The basic combat service support disposition arrangement, characteristic of the offensive operation and the march and consisting in the fact that medical support means are positioned closer to the combat formations, is also maintained for the defense. Areas difficult of access to tanks, containing good natural and man-made cover, should be designated for positioning combat service support elements. Rear services subunits should be positioned dispersed in the designated area. Particular attention is focused on dispersing and sheltering ammunition and fuel. In the absence of cover and shelters, obviously combat service support elements will take steps to construct shelters when occupying these areas.

In order to accomplish an organized shift of areas occupied by combat service support elements on enemy penetration or if a complex radiation situation occurs, alternate combat service support deployment areas are prepared.

Special attention in the defense is devoted to preparing and maintaining supply and evacuation routes. If it is impossible to use the main routes, alternate routes are designated. If it is not possible to use ground lines of communication, foreign military experts note, hauling of supplies and medical evacuation will be accomplished with helicopters.

Combat service support deployment areas are particularly in need of reliable cover with antiaircraft weapons. As regards security and defense, they are usually provided by the personnel and equipment of the combat service support elements. In some cases combat subunits may be designated for security and defense of the combat service support deployment area and supply routes.

The experience of the Great Patriotic War indicated that a characteristic feature of supply activities in the defense is a higher expenditure of ammunition and engineer equipment than in the attack. Therefore larger stocks of these supplies can be established in the combat units when shifting to the defense; ammunition can be stacked right on the ground at artillery and tank fire positions.

Maintenance support of tank troops is also organized under no less difficult conditions. It is believed that characteristic features of these conditions include substantial losses of equipment in the course of preceding combat actions, a high intensity of efforts by maintenance elements on repairing this equipment, as well as the possibility of continuous enemy action against maintenance personnel and equipment.

One of the principal tasks of maintenance support in the defense is that of making vehicles combat ready and ensuring their reliable operation both in the course of defensive combat and with a shift to the attack. Usually when subunits occupy their designated defensive areas, vehicles are inspected, spotted malfunctions are corrected, ammunition is replenished, and all vehicles are refueled and lubricant levels topped off. The sequence of tank servicing operations is set up so as not to impair troop combat readiness. Trucks engaged in hauling supplies should be serviced after completing their hauling tasks.

When it is necessary to service tanks during defensive combat, it is believed that servicing operations will be performed during breaks between action directly in the combat formations or behind nearby cover.

As is indicated by the experience of the past war, a priority task when troops shift to the defense under conditions of close contact with the enemy is recovery, under cover by combat troops, of vehicles which have become disabled during preceding actions. All damaged and disabled vehicles, regardless of the nature of the damage or breakdown, are first of all evacuated from the defensive areas of the combat subunits, with subsequent evacuation to damaged vehicle collection points.

Repair of vehicles which have become disabled during defensive combat can be accomplished by repair and recovery teams behind cover and in shelters, and by other maintenance personnel and equipment at damaged vehicle collection points.

Vehicles which have received damage in defensive combat are as a rule recovered and evacuated in two stages. Initially they are recovered from under hostile fire into shelters or behind cover, and subsequently are evacuated to repair locations. Priority in recovering damaged vehicles goes to those which cannot continue fighting as a consequence of sustained damage.

It is stated in the foreign military literature that maintenance locations for repairing equipment are selected so that they are provided cover by support echelons or reserves, so that temporary situation changes in the course of defensive combat caused by enemy penetration cannot disrupt their normal operations. It is most expedient to select tracked vehicle repair locations in an area on the axis of concentration of main combat efforts, with cover provided by support echelons or reserves. Repair locations for trucks and other equipment will usually be designated in the combat service support deployment area. Evacuation routes are

designated, and constructed if necessary, for evacuating vehicles from the forward-echelon troops to damaged vehicle collection points.

During defense on a broad frontage, in order to reduce evacuation distance, it is recommended that repair personnel and equipment be divided into two independent groups, including in each group equipment for repairing armored vehicles and trucks. In selecting locations for deployment of repair equipment, one should extensively utilize terrain protection and concealment properties, which will make it possible to reduce expenditure of manpower and resources on setting up shelters and performing camouflage activities, and will speed up repair of equipment.

Maximum duration of repair work performed in the defense depends on the tactical situation, the number of damaged vehicles, and their condition. When troops are firmly holding their defended sectors and during protracted defensive fighting, maintenance subunits can perform minor repairs and routine maintenance on vehicles without restrictions, and in certain cases limited-extent medium repairs as well.

Upon enemy penetration of the defense, recovery and evaluation means direct their principal efforts at rapid and prompt recovery and evacuation of damaged vehicles from threatened areas, in order to prevent the enemy from capturing and destroying these vehicles. In this case repair and recovery teams prepare all damaged vehicles for evacuation or movement to collection points under their own power.

CONCLUSION

The view prevails among many foreign military experts that tanks are a versatile weapon and therefore will long remain the principal striking force of ground troops in modern warfare. The opinion is stated that no army in the world can count on success without possessing a powerful tank fleet. The events in the Near East are cited to bolster the claim that success in combat operations has been determined precisely by the employment of tanks in mass, operating in skillful coordination with other arms.

It is believed that under present-day conditions, when combat operations will develop across a broad frontage and to considerable depth, only highly-mobile tank troops, reinforced by other weapons, will be able successfully to accomplish the assigned missions, for they possess great striking power, good mobility, maneuverability, and personnel protection. The development of tank troops is continuing in all countries.

Two trends exist today in views abroad on the evolution of tanks and tank troops -- standardization of combat vehicles, combat units and combined units, and intelligent diversification of combat vehicles and organizational forms of troops.

The first trend -- standardization not only of combat vehicles, and particularly tanks, but also of combat units and combined units -- essentially leads to a single type of combat vehicle and a single type of combat combined unit. It is most vividly manifested, for example, in the British Army.

The significance and positive aspects of standardization, especially in the area of weapons and equipment, are stressed in the foreign press. At the same time it is noted that there should be certain limits to this standardization. Standardization is compared with the development of science. Science accomplishes its assigned tasks by means of specialization and division into separate fields. Such specialization makes it possible, utilizing special tools of investigation for each set of concrete conditions, to penetrate more deeply into the essence of phenomena and to solve individual problems more concretely. Mankind, in the process of the industrial revolutions which have taken place, has not arrived at one mode of transportation, one or only a few implements of production. Man creates unique implements of labor and machines for each production task.

The following question is asked in connection with this: why is it that the military, while possessing knowledge of these quite obvious facts, attempts to accomplish all the diversified combat missions on today's battlefield and under various natural conditions, with one type of combat vehicle and one (standardized) organization of troops?

Such a one-sided standardization is considered useful only up to certain limits, since it is considered impossible to expect one and the same combat vehicles, combat units and combined units to operate with identical success in the North and South, on flatland terrain, on forested-mountainous terrain, or in deserts.

Hence the conclusion that the second trend (intelligent diversification in weapons, combat equipment, and troop organization) is more acceptable and therefore more lasting as well.

In order to refute the predictions of some military theorists that the appearance of ATGM on the battlefield will end the domination of tanks, reference is made to the events in the Near East, where both sides employed substantial numbers of antitank guided missiles. It is claimed that these events demonstrated that with skillful organization of combat against ATGM, tanks will continue for quite some time to come to be the main striking force of ground troops on the battlefield.

Foreign military thought expresses the view that tank troops will pass through several additional stages of improvement in their development and that it is patently premature to state that they have exhausted all their capabilities. It is stated that actual events indicate the opposite, for in actual fact combined-arms large units and formations equipped with tanks and other armored fighting vehicles are more and more fully adopting both organization for combat and principles of conduct of combat precisely from tank troops. It is claimed that there is taking place a process of "armorization" of combined-arms large units and formations, their gradual but steady approach to tank troops.

As a consequence, the trend toward standardization can be viewed not as the necessity of developing a single type of combat vehicle or a single organizational form of troops, but rather as an endeavor to utilize the same parts, assemblies and units in weapons which differ in function and type, and uniform special subunits and combat units of arms in military organisms of differing function. It is assumed that precisely such standardization will produce maximum effect.

The authors hope that this study will provide the readers with a wealth of food for thought and ideas both in the area of designing new equipment, equipment operation and maintenance, and in the organization, tactics and operational art of tank troops. Here too various specialists are faced with a number of major tasks, which can be accomplished only with painstaking daily work on the part of all tank troops officers and the tank building team.

The layout arrangements of combat vehicles, expedient placement of crew members, securement of personnel survivability and life support, installation of the most optimal weapon systems, securement of a high degree of vehicle mobility and maneuverability, including air transportability, and equipping combat vehicles with modern communications and navigation gear -- these are the items which the foreign

military press recommends that tank industry designers and engineers tirelessly work on.

Study, development and adoption of new, improved methods of operation, maintenance, repair and recovery of combat vehicles in the course of combat training and troop combat operations should constitute urgent tasks of military engineers of units, combined units and training institutions.

Finally, elaboration of new points of theory and practice of employment of tank troops in the engagement and operation is the primary business of commanders and staffs of all echelons and places new tasks before them. Utilization of modern operations research methods will make it possible to find the most optimal methods of utilization of tank troops. Theory of utilization of tank troops should be based on a reliable mathematical edifice, experience of troop combat training, and the development prospects of military affairs.

3024
CSO: 8144/0497

- END -

DISTRIBUTION LIST

DIA

B737 DIA/RTS-2B (LIB) (5)

U & S COMMANDS

H005 USCINCEUR (2)
H300 ODCS IN(USAREUR) (2)
H303 502D I&S BN (PROV) (2)
H306 DCSI US COM BERLIN (2)
H317 439TH MID (STRAT) (2)
H320 66TH MI GP (2)
H336 404TH MID (STRAT) (2)
H350 SFDET (ABN) EUR (2)
H524 HQ V CORPS (2)
H525 HQ VII CORPS (2)
H526 HQ 3RD INF DIV (2)
H528 1ST INF DIV (FWD) (2)
H529 HQ 3RD ARMORED DIV (2)
K010 USFK (2)
K300 IPAC (LIBRARY) (2)
K302 USAWESTCOM (2)
K320 USARJAPAN (2)
K342 2ND INF DIV (2)

ARMY

C020 DCS-OPS & PLANS (3)
C030 CH RD&A (2)
C043 USAMIIA (2)
C054 HEALTH CARE OPS (2)
C061 MP SCH (2)
C085 USAMSAA (2)
C090 TECOM/BEEO (2)
C202 III CORPS (2)
C227 101ST AIRBORNE DIV (2)
C231 2ND ARM DIV (2)
C234 1ST CAV DIV (2)
C235 1ST INF DIV (2)
C238 364TH MI CO (TI) (2)

ARMY (CONT'D)

C239 11TH MI BN (PROV) (2)
C241 FIRST US ARMY (2)
C242 FORSCOM (2)
C243 FIFTH US ARMY (2)
C245 OPPOSINGFORCTNGDET (2)
C246 6TH CAV BDE (AC) (2)
C276 312TH MID (BDE) (2)
C277 344TH MID (SB) (2)
C303 4TH PSYOP GROUP (2)
C304 5TH PSYOP GROUP (2)
C305 18TH ABN CORPS (2)
C306 82ND ABN DIV (2)
C307 24TH INF DIV (2)
C309 500TH MIG (2)
C348 453D MID (2)
C351 10TH SFG(ABN)1STSF (2)
C356 479TH MID (STRAT) (2)
C414 4TH INF DIV (2)
C415 5TH INF DIV (2)
C417 7TH INF DIV (2)
C419 9TH INF DIV (2)
C428 OP TEST&EVAL AGCY (2)
C442 USAFS MISAWA (2)
C454 FLD ARTY SCH (2)
C459 COMD-GEN STF COL (2)
C460 ENGINEER SCH (2)
C461 INFANTRY SCH (2)
C470 ARMY WAR COL (2)
C500 TRADOC (2)
C505 AMMRC (2)
C507 USAITAC (GIPD) (2)
C509 BALLISTIC RES LAB (2)
C510 R&T LABS/AVRADCOM (2)
C512 DARCOM (2)
C513 ARRADCOM (2)
C515 CHEMICAL SYS LAB (2)
C517 BENET WEAPONS LAB (2)
C522 YUMA PG (2)
C523 ERADCOM/FI-A (2)
C532 MEW ELCT WAR LAB (2)

ARMY (CONT'D)

C535 AVRADCOM/TSARCOM (2)
C538 WHITE SANDS MSL RG (2)
C539 TRASANA (2)
C545 ARRCOM (2)
C547 ARMY NUC&CHEM AGCY (2)
C550 ERADCOM/FI-M (3)
C557 USAITAC (IIPD) (2)
C562 TRANS SCH (2)
C569 MERADCOM (2)
C587 CMBT DEV EXPR COMD (2)
C590 USATAC (2)
C591 FSTC (2)
C605 JFK CTR MIL ASSIST (2)
C617 CONCEPT ANALYS AGCY (2)
C619 MIA REDSTONE (5)
C620 USAITAC (SRD) (2)
C623 USAOG (2)
C632 CHEMICAL SCHOOL (2)
C633 ORDNANCE CTR & SCH (2)
C635 AIR DEF AGCY (2)
C639 CMBT&TNG DEV DIR (2)
C641 AVIATION CTR&SCH (2)
C644 LOG CTR (2)
C646 CACDA (2)
C667 USAIMA (3)
C683 INTEL CTR&SCH (4)
C684 USAISD (2)
C697 TEST & EVAL COMD (2)
C715 ARMOR CTR (2)
C748 HQDA DAMI-FRT (2)
C755 902D MIG (2)
C756 900TH MI CO (2)
C757 SED (2)
C763 HQDA DAMI-FIT (2)
C766 HQDA DAMI-FIC (2)
C768 USAITAC (LIB) (2)
C819 5TH SFG(ABN)1ST SF (2)